INSTRUCTIONS
For the
CARE and OPERATION of
Model – H Hispano-Suiza
AERONAUTICAL ENGINES

Wright-Martin
Aircraft Corporation
New Brunswick ~ New Jersey, U.S.A.

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Hispano-Suiza

AERONAUTICAL ENGINES

BIRKIGT PATENTS

INSTRUCTION BOOK

SEPTEMBER, 1918

SERIES No. 6H

Wright-Martin Aircraft Corporation

New Brunswick New Jersey, U. S. A.

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INTRODUCTION

The remarkable progress that has taken place in the field of aviation during the past few years has been due largely to the rapid developments made in aeronautical engines.

Most of the early aeroplanes were equipped with rotary engines. These engines had the advantage of being light in weight, but they lacked power and reliability. Moreover, they were uneconomical in oil and gasoline. It soon became apparent that any further progress in aeronautical engines must necessarily come from developments along the lines of the more powerful stationary engines.

During the spring of 1916, the Societe Hispano-Suiza of France presented the first Hispano-Suiza engine to the Technical Section of the French Aviation. This was a stationary "V" type engine of 150 H. P.

This type "A" Hispano-Suiza was soon after adopted by the French military authorities. Fitted on the Spad plane, it was brought up to the front in August 1916, and underwent the most severe practical tests during the battle of the Somme.

It was due largely to the performance of the Hispano-Suiza engine during this battle that the French were able to gain the supremacy of the air.

The success of the type "A" 150 H. P. having been fully demonstrated, the Societe Hispano-Suiza began experimenting with a more powerful engine and in December, 1916, a new Type "E" 180 H. P. engine was produced.

In general construction this engine was practically the same as the former Type "A," but the compression had been increased, and a larger carburetor had been added. The engine was designed to run 300 revolutions faster, and was correspondingly reinforced.

This engine gave more satisfaction than the first one. It had the great advantage of having high compression and allowed the pilot to keep his power at high altitudes. The Germans at that time did not have such fast machines, and were trying to get the advantage in altitude. On that point they were also beaten. Between 15,000 and 18,000 feet, where most of the fighting took place, the performance of the Hispano-Suiza engine was absolutely uniform and reliable.

In March, 1917, the Societe Hispano-Suiza produced a 200 H. P. engine, which permitted an extra gun to be carried. This engine was used throughout the Battle of the Aisne and in Flanders. In July a new type of 200 H. P. was manufactured. This was the 200 H. P. high compression engine. Very soon after the appearance of this engine, tests were made on the 300 H. P. Hispano-Suiza engine in service at the front at the present time.

The original Societe Hispano-Suiza not having had the facilities for turning out their engines in sufficient quantities to meet the demands of the French and allied nations, rights were given to other companies in France and to the Wright-Martin Aircraft Corporation of America.

The Wright-Martin Aircraft Corporation is building not only for the great work of the present, but for the greater work of the future.

This Company represents one of the pioneers and leaders in what will be, during the years to come, one of the world's foremost industries.

WRIGHT-MARTIN AIRCRAFT CORPORATION,

New Brunswick, N. J., U. S. A.

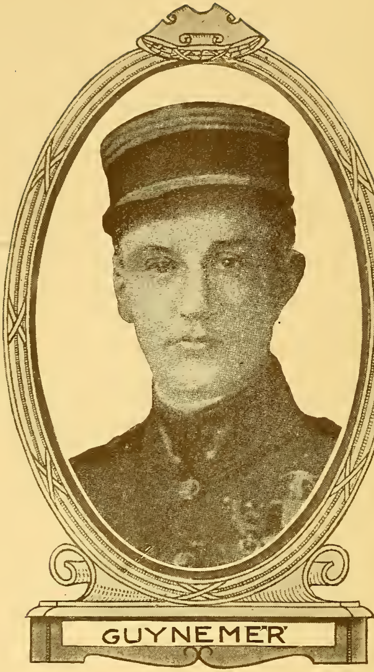
The following photographs represent only a few of the Aces who have staked their success and reputation upon the Hispano-Suiza engines.

(59 Boches)

Born the 27th of March, 1894, at Sauley-sur-Meurthe: pilot of remarkable bravery and daring, having fought many aerial duals. Rendered the greatest services to his country during the early part of the war, making daily reconnoitering flights over enemy territory in the face of great danger.

Lately awarded the Serbian Cross of Karageorgevitch and another bar to the English Military Medal.

Citation—"At the present time the most decorated of our pilots, having fought with valor on the English, French and Belgian fronts."



GUYNEMER

(53 Boches—20 Citations)

(Born in Paris, December 24, 1894)

"Captain Guynemer, commanding escadrille No. 3, died gloriously after three years of arduous fighting. He will remain the purest symbol of the qualities of the race: Unconquerable tenacity, fierce energy, sublime courage. Animated by a most unfailing faith in Victory, he leaves to France a lasting remembrance which has exalted the spirit of sacrifice and steadfastness among the soldiers of France." Last citation.

Following Decorations:

War Cross with 25 palms
Military medal (July 21, 1915)
Chevalier of the Legion of Honor (Dec. 24, 1915)
Chevalier of the Danile de Montenegro
Cross of Saint-George of Russia
Cross of Mitchell the Brave of Roumania
Star of Kara George of Serbia, (Mar. 21 1917)
Officer of the Legion of Honor, (June 11, 1917)
Distinguished Service Order (August 1917)

(39 Boches)

Remarkable example of physical and moral energy, courage, audacity and coolness, which characteristics have won him his name of "King of the Air." Few pilots put more variety into their system of attack.

Although convalescing from serious wounds, fought every day and in many cases executed flights which lasted nine hours.

Served in two branches of the army, having first enlisted at the outbreak of the war n the 2nd Regiment of the Hussars. After the death of George Guynemer, the title of Ace of Aces passed to Nungesser.

His victories were accomplished under conditions which called for skill, endurance and heroism.

Military medal gained when with the Hussars after one month's fighting. Croix de guerre with 16 palms and 2 stars, Military cross of England, Crown of Leopold with silver palms, Belgian Croix de Guerre, Danilo de Montenegro, la Bravoure Serbe, Italian Cross of Valor, Cross of St. George of Russia, and the Legion of Honor.

(38 Boches)

Born at Bizerte, 25 years ago; from the very outbreak of the war Madon distinguished himself by his fearlessness and made a name for himself by the aerial acrobatics which he performed. He was attached to the Soissons sector.

In April, 1915, was lost in a mist and forced to land in Swiss territory. He escaped the following September. Returned to France and joined his former unit. He soon began to distinguish himself as a Boche hunter.

(25 Boches)

(Born at Havre the 25th of July, 1892)

Before entering aviation Lieut. Guerin was cited twice for brilliant action in infantry. "He is one of our most remarkable aces, having been one of the quickest in bringing down enemy planes. Has fourteen citations to his credit, military cross and legion of honor."

(23 Boches)

When Rene Dorme was killed he had to his credit 23 Boches officially recorded. One might say, without exaggeration, that he had brought down twice that number. An indefatigable fighter, one who fought, not to have his successes recorded, but to bring down the greatest possible number of Boches. At the time of mobilization, he was a volunteer and succeeded in getting a transfer in the aviation in 1915, commissioned and attached to a camp near Paris with several pilots who had made big names for themselves.

Citation promoting him to the Legion of Honor: "Brilliant pilot with exceptional skill and audacity. Always ready in all weather and under all circumstances for the most daring missions."

(21 Boches)

Captain Heurtaux who succeeded Commandant Brocard as chief of the famous Stork escadrill No. 3, is one of the youngest and most remarkable of French Aces.

"The 2nd Lieut. Heurtaux has proven himself bold and energetic. He was the first to bring down an enemy aeroplane with a single bullet, a feat which only Guynemer has equalled. Heurtaux is called "the terror of the enemy."

Citation—Upon receiving the Order of Legion of Honor: "As a Cavalry officer, he proved his qualities of audacity, coolness and devotion, which earned him three citations. In aviation since December, 1914, has distinguished himself as an observer, a bomber, and pilot of exceptional ability."

(21 Boches)

(*Italian Ace*)

LUFBERY

(19 Boches)

(Born in Wellingford, Conn., volunteered at the outbreak of the war as a mechanic for the famous French Aviator, Marc Pourpe)

Upon Pourpe's death he asked to become pilot to revenge his friend's death. Distinguished himself by long-distance bombing expeditions and daily combats with enemy aviators. He proved himself a remarkable pilot and was quick to win the military cross. The first American volunteer in the French Army to receive the English military cross. Lufbery's history is one of the most interesting among the Americans enrolled in the French Flying Corps.

Citation—"Of exquisite calm and even character, cool judgment coupled with exceptional bravery. In addition he was an excellent marksman. One of the most popular of the Americans in the French Esquadrille and admired by all who knew him."

(18 Boches)

(17 Boches)

(Born May 29, 1897)

Prisoner in Germany for eighteen months, escaped and reached France on the 10th of April, 1916. One month after his return to France, although still weak from privation of his prison life in Germany, he returned to the front where he soon distinguished himself by numerous victories.

(12 Boches)

Lieut. Flachaire, one of the most daring of French pilots, having 12 Boches to his credit. He demonstrated his flying qualities with his Hispano-Suiza equipped Spad to thousands in America.

(12 Boches)

(11 Boches)

VITALIS

(7 Boches)

(Born at Lodove, February 15, 1890)

Flier of exceptional daring, fought many aerial duels in the course of which his plane was frequently riddled by enemy bullets. Was an expert marksman.

Active at Verdun and at the Somme.

(7 Boches)

(Born the 27th of August, 1897, at Sainte Antoine)

Although only eighteen when he enlisted he soon acquired all the gifts required for aerial fighting—physical endurance, marksmanship, courage and tenacity. The career of Garaud was short but eloquent. The heroism and loyalty of this young man have served as a model to all the youths of France enlisted in aviation.

(7 Boches)

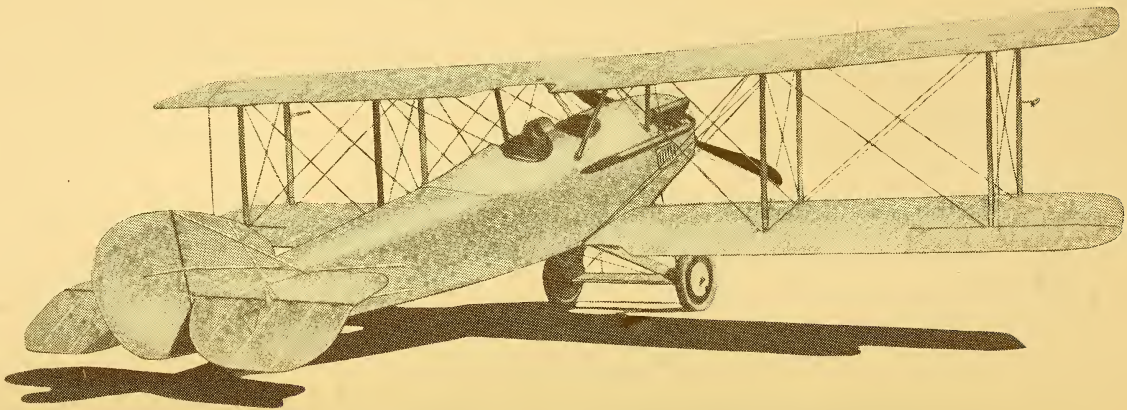


Plate 1

Aeroplane equipped with Hispano-Suiza Engine

PREFACE

Pilots and owners will understand that it is impossible to lay down absolute rules for the proper care of engines that will cover all the wide and varying conditions of air service which must be met with.

The Instruction Book which is placed in the tool equipment of each Hispano-Suiza Engine is intended to be suggestive only, and we expect the instructions to be modified to meet the particular conditions under which each engine is operated.

To insure to every Hispano-Suiza owner the full benefit of the remarkable service which this engine is capable of delivering, the Technical Service Department of the Wright-Martin Aircraft Corporation will furnish, upon request, any information concerning the care and operation of the Hispano-Suiza Engine under special conditions of service.

It is well to remember that continued efficiency is best assured when replacements are made with the standard Hispano-Suiza parts manufactured by the Wright-Martin Aircraft Corporation.

WRIGHT-MARTIN AIRCRAFT CORPORATION

New Brunswick, N. J., U. S. A.

INDEX

INSTRUCTIONS

FOR THE

CARE AND OPERATION

OF

MODEL H—300 H. P.

HISPANO-SUIZA

AERONAUTICAL ENGINES

PART I

UNPACKING

Shipping Weight and Size.

The shipping weight of the Model "H" 300 H.P. Hispano-Suiza Engine, is about 950 lbs.

The Hispano-Suiza Engines are shipped from the factory completely enclosed in a substantial box fitted with permanent slings. The engine itself is covered with a water-proof oil cloth. The dimensions of the shipping box are:

Length	57½"
Width	43½"
Height	44"
Displacement	63½ cu. ft.

To unpack, cut the two sealing wires, which will be found under tin plates at each end of the box. Remove eight lag screws in the sides of the box. The engine will be found securely bolted down with six bolts to supports or sills fastened and braced to skids, the skids being fastened to the sides of the box with the above-mentioned eight (8) lag screws. The end of the shipping box can be removed by removing the wood screws in the end. The complete engine with engine bed can be removed through the end of the shipping box. Remove the nuts of the engine bed bolts and place two cables around each side of the engine between two or three of the steel sleeves. The engine can then be lifted with a suitable hoist.

What to Rest the Engine On.

Do not attempt even to partially rest the weight of the engine on the lower half of the crankcase or any part other than the separating flanges on the upper half of the crankcase.

Where Parts are Found in Packing Box.

At the rear of the shipping box at the top will be found the spare parts and tool equipment box.

The following parts will be found to be covered with paper:

Carburetor air inlet.
Water pump.
Tachometer drive.
Crankcase breather.
Air pump.
Magnetos, magneto drive.
Vertical shaft casings.
Propeller hub.

Solid fibre gaskets are placed over the exhaust parts and water outlets and should be removed.

Removing Oil from Outside of Engine.

The interior of the cylinder sleeves (steel) are slushed with one-half pint of castor oil before shipping. This oil can be removed from the engine by removing the outside spark plugs and turning the engine over a number of revolutions as fast as possible.

This oil can be caught in a can at the spark-plug hole and if properly cleaned used for engine lubrication.

Before shipping the Hispano-Suiza Engines, all the steel and aluminum parts are slushed with heavy oil. A spray of gasoline under air pressure will remove this from the engine. If the engine is to be started immediately after washing, keep the magnetos from getting gasoline in them, otherwise there will be danger of fire.

PART II

GENERAL DESCRIPTION

The Model "H" Hispano-Suiza Aeronautical Engine is of the eight-cylinder "V" type, four cycle, water cooled, bore 140 m/m 5.511", stroke 150 m/m 5.905". At sea level it develops 300 H.P.

There are two cylinder blocks, each containing four cylinders, their center lines making an angle of 90° between them.

Cylinders.

The individual cylinders are steel forgings, heat-treated, machined and threaded on the outside. These steel sleeves are flanged at the bottom and closed at the top, this surface being flat, providing for the two valve seats. The cylinders are screwed into the cast-aluminum cylinder blocks which form the water jackets and valve ports, as well as intake and exhaust passages. Each block, after cylinders and other parts are assembled, is given several coats of enamel, both inside and out, each coat being baked on.

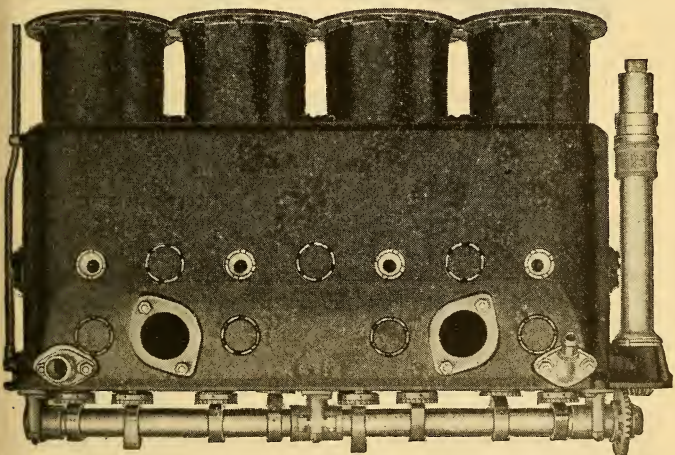


Plate 1

Cylinder, steel sleeve, vertical shaft and camshaft assembly

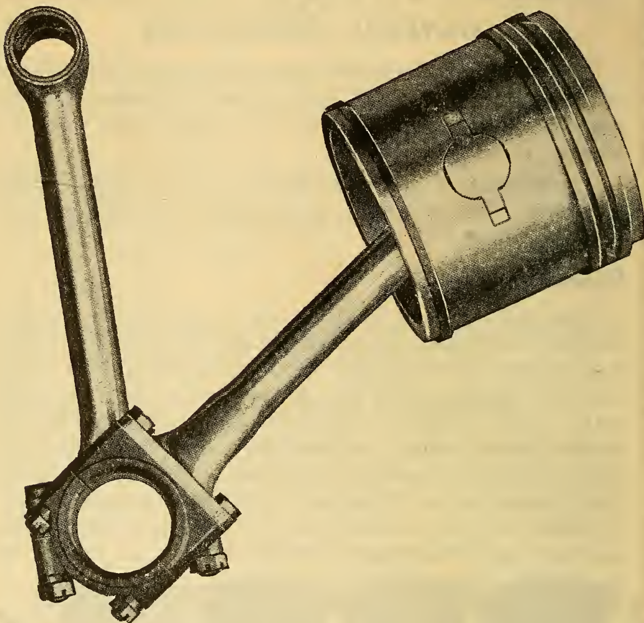


Plate 2

Piston and connecting rods assembled.

Pistons.

The pistons are aluminum castings, one-half of an inch in thickness at the head. The sides taper down from one-half of an inch at the top to three-sixteenths of an inch in thickness at the bottom. By this construction the heat is rapidly carried off. At the top of each piston are three rings. Near the bottom there is one oil ring, the piston being relieved just below it.

The piston pins are made of case-hardened alloy steel, large in diameter, and hollow. They are allowed to float in both sides of the pistons as well as the upper end of the connecting rods. Each is held in place by an aluminum plug in each side of the piston. See Plate 2.

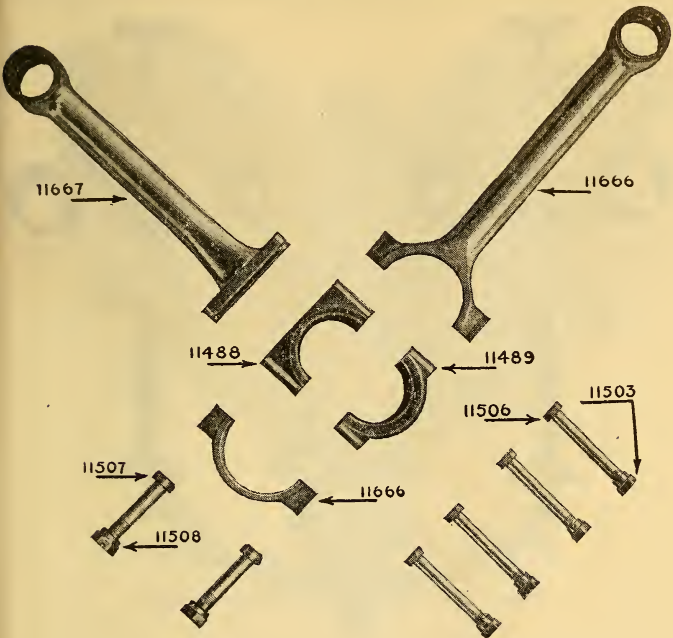


Plate 3

Inner and outer connecting rods disassembled.

Connecting Rods.

The connecting rods are of heat-treated steel, tubular in section. One rod is forked at the bottom end, having a two-piece bronze box (babbitt lined) bolted to it by four bolts. This bears directly on the crankshaft. The other rod bears on the outer and central portion of the bronze box. Both connecting rods are provided with bronze bushings at their upper ends.

Crankshaft.

The crankshaft is of the four-throw type, 180° between throws. It is made of chrome nickel steel, machined all over, and is hollow for lightness, also

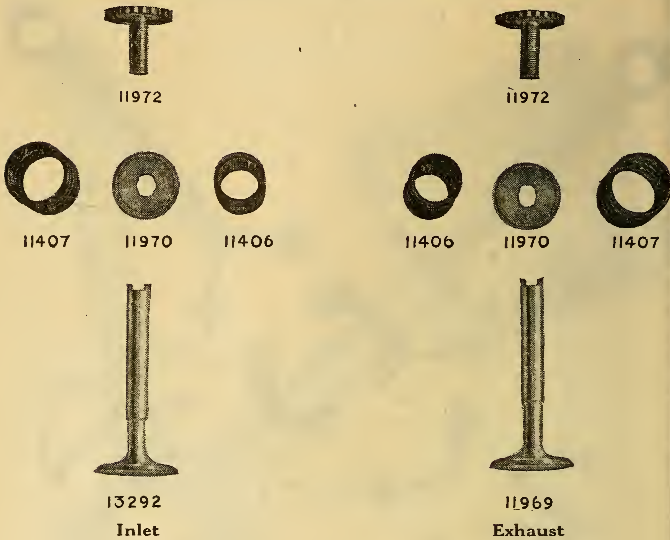


Plate 4

Valves, valve springs and valve tappets disassembled.

allowing the lubricating oil to get from the main bearings to the connecting-rod bearings.

This shaft has four plain main bearings, bronze backed and babbitt lined, and one annular ball main bearing at the rear (magneto) end. It is provided with a taper having a key for the propeller hub.

The thrust for either a tractor or pusher propeller screw is provided for by a double row ball-thrust bearing located in the front of the crankcase.

Crankcase.

The crankcase is of aluminum and is made in halves, the division being on the center line of the crankshaft. The main bearings are supported in both the upper and lower halves.

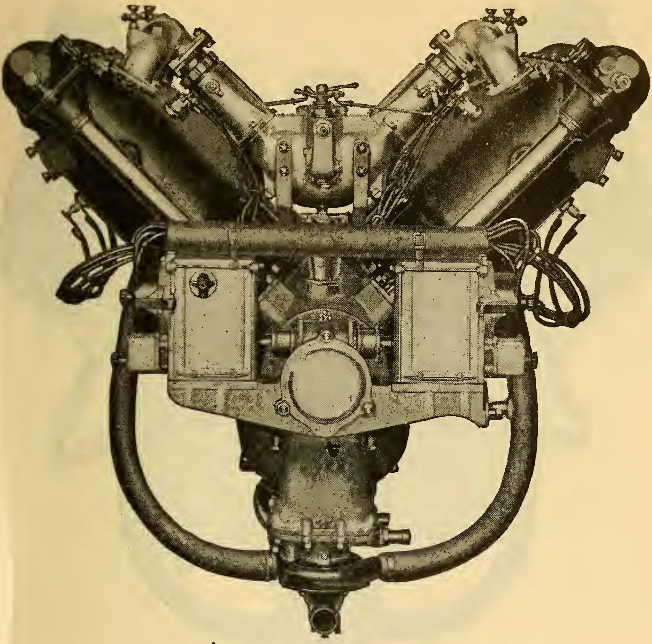


Plate 5
Rear view of engine

Magneto Support and Drive.

The magneto support is an aluminum casting bolted on the rear end of the crankcases. A small shaft, with a spiral gear, driven from the end of the crankshaft is mounted in the center of the magneto support. This shaft drives, by means of the spiral gear, another shaft which is at right angles to it and directly above it.

The magnetos are driven from this upper shaft through gear type couplings.

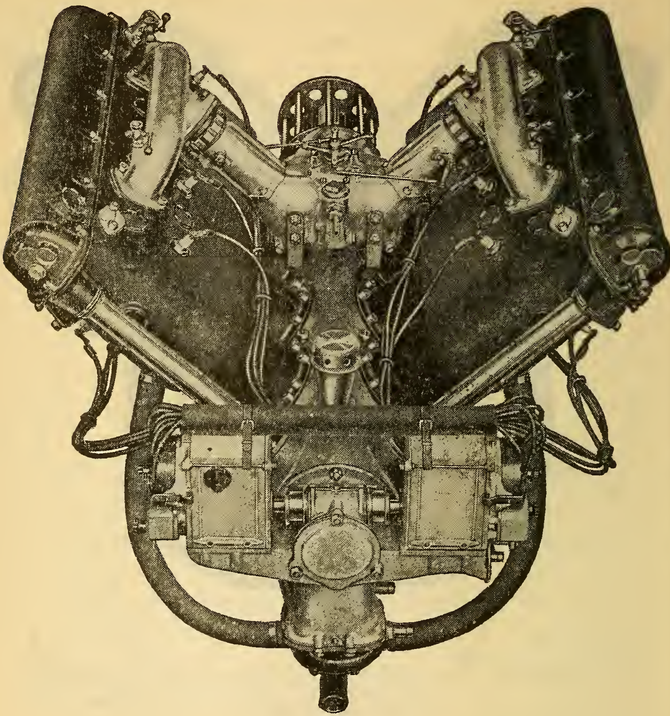


Plate 9

Three-quarter top view of engine from rear.

Valves.

The valves are set vertically in the cylinders along the center of each block and are directly operated by a single, super-imposed camshaft. The valves are Tungsten Steel, with large diameter hollow stems, working in cast-iron bushings, provided at the upper ends with case-hardened flat-headed adjusting screws (discs) upon which the cams are operated. To insure proper seating, the valves are held to their seats by two concentric helical springs each, either one of which is sufficient to insure the valve seating in case of breakage to the other.

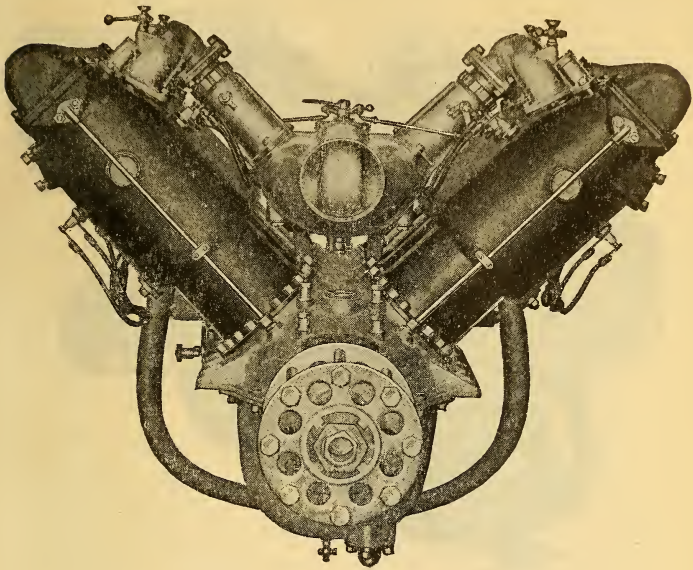


Plate 7
Front view of engine.

Ready adjustment of clearance between the adjusting screws or discs and the cam contour is obtained by serrated washers. These washers are pressed upward by springs and hold the adjusting screws in place while they permit easy turning by means of a special wrench which angularly displaces the adjusting screws in the stems of the valves. The spring retainer washer is held in place angularly by means of tenons which engage slots in the stem. Nevertheless, the whole assembly can slide freely lengthwise. It is the valve spring which holds the spring retainer to the adjustment disc, the rim of which is arranged with small indentations.

Camshafts.

The camshafts are hollow and are supported by three plain bronze bearings each. The drive for each shaft is

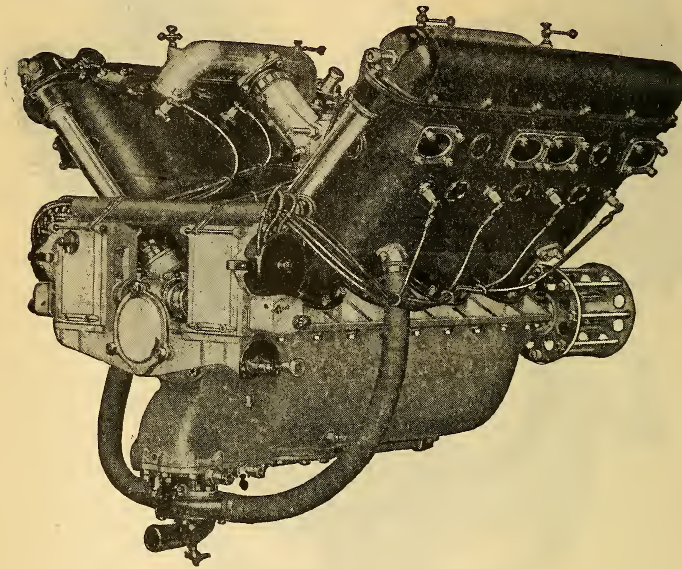


Plate 8
Right side of engine.

by means of a pair of bevel gears and a vertical shaft driven from the crankshaft by a vertical shaft and bevel gear of hardened alloy steel running in plain bronze bearings. These shafts are protected by a housing of light steel tubing and each one is provided with a screw-driver type of joint near the middle, allowing ready removal of the cylinder blocks without dismounting other parts. The camshafts, cams and heads of the valve stems are all enclosed in oil-tight cast-aluminum removable housings.

Tachometer.

Each valve gear housing is provided with a dog clutch tachometer drive operated by the camshaft.

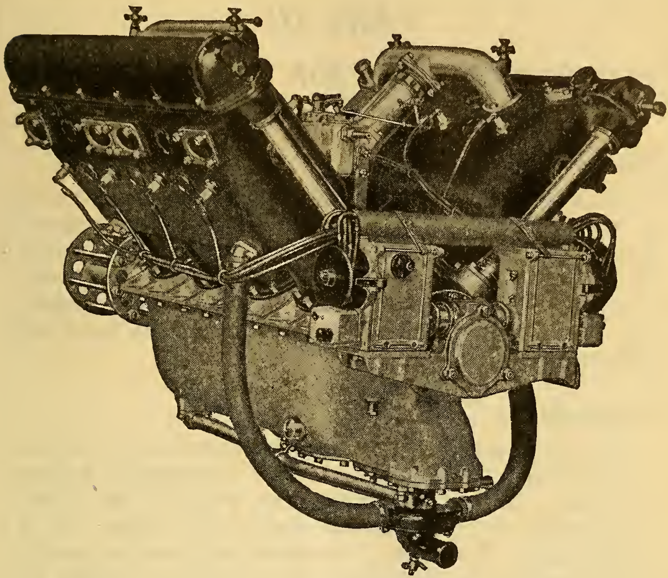


Plate 9
Left side of engine.

Propeller Hub.

The propeller hub is fastened directly on the tapered crankshaft end by means of a key, being drawn on by a nut having a coarse pitch thread on the inside and it being locked by a second nut having a fine pitch thread on the outside which screws directly into the propeller hub.

Exhaust.

The exhausts have individual ports to which are attached steel manifolds adapted for each particular type of airplane.

PART III

RECOMMENDATIONS FOR INSTALLING THE ENGINE IN THE AIRPLANE

How Mounted.

The engine should be anchored on a rigid support and at the points of contact with the engine the support should be lined with fibre or sheet metal. The engine base should set flat on the engine support members. Contact should be made at all places between engine base and supports before the nuts holding the base are tightened.

Accessibility.

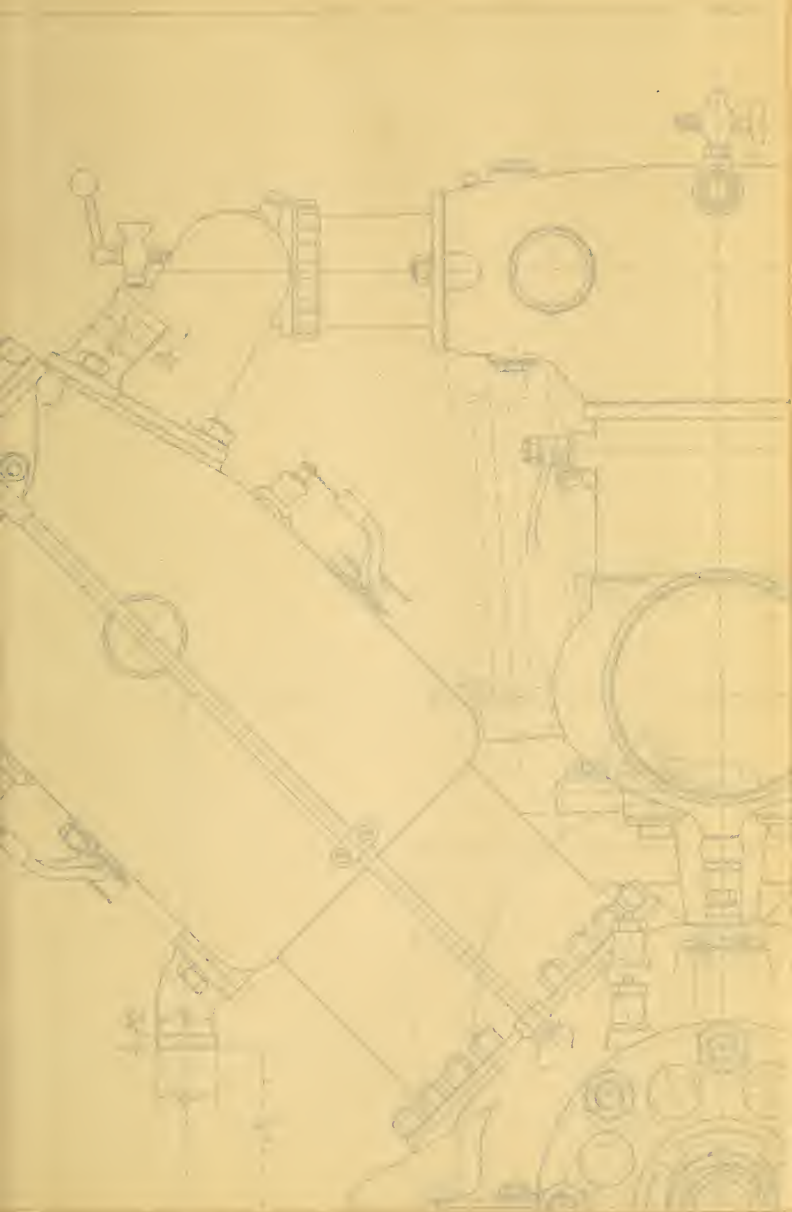
Whenever possible, the camshaft housing or cylinder covers should be left exposed; their disassembly is then very easy and this arrangement permits the plane constructor to cut down the size of the cowls. If, in certain cases, the engine is mounted without any cowls, some method of sheltering the magnetos should be provided for, such as a leather covering.

The plane should be so designed that the following parts are easily accessible: Magnetos, particularly the distributors and breaker boxes, spark plugs, oil filter chamber cover 11749, oil pressure relief cap 11893, and crankcase breather tube cap A-9960-B.

Protection from Fire.

The plane should be protected from back-fires by having a long screen or similar device placed over the air inlet of the carburetor, the minimum inside diameter of which should be 127 m/m or 5″, having a length of 203 m/m or 8″, with a steel disc placed in the one end.

At the lower part of the carburetor is a nipple to which a small drain tube should be fastened to carry off the gasoline. This tube should discharge well to the rear under the planes, and as far away from the exhaust as possible.



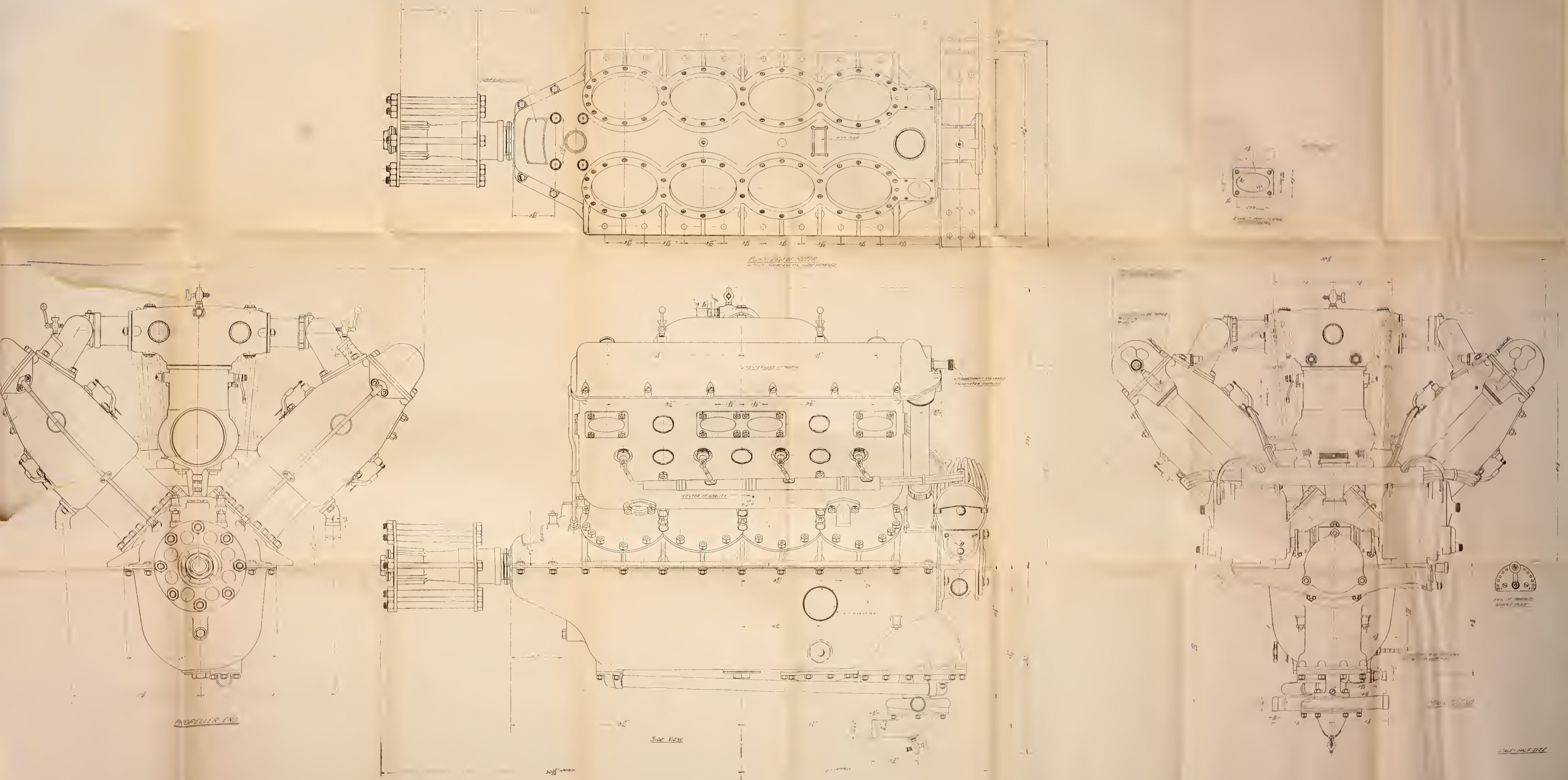
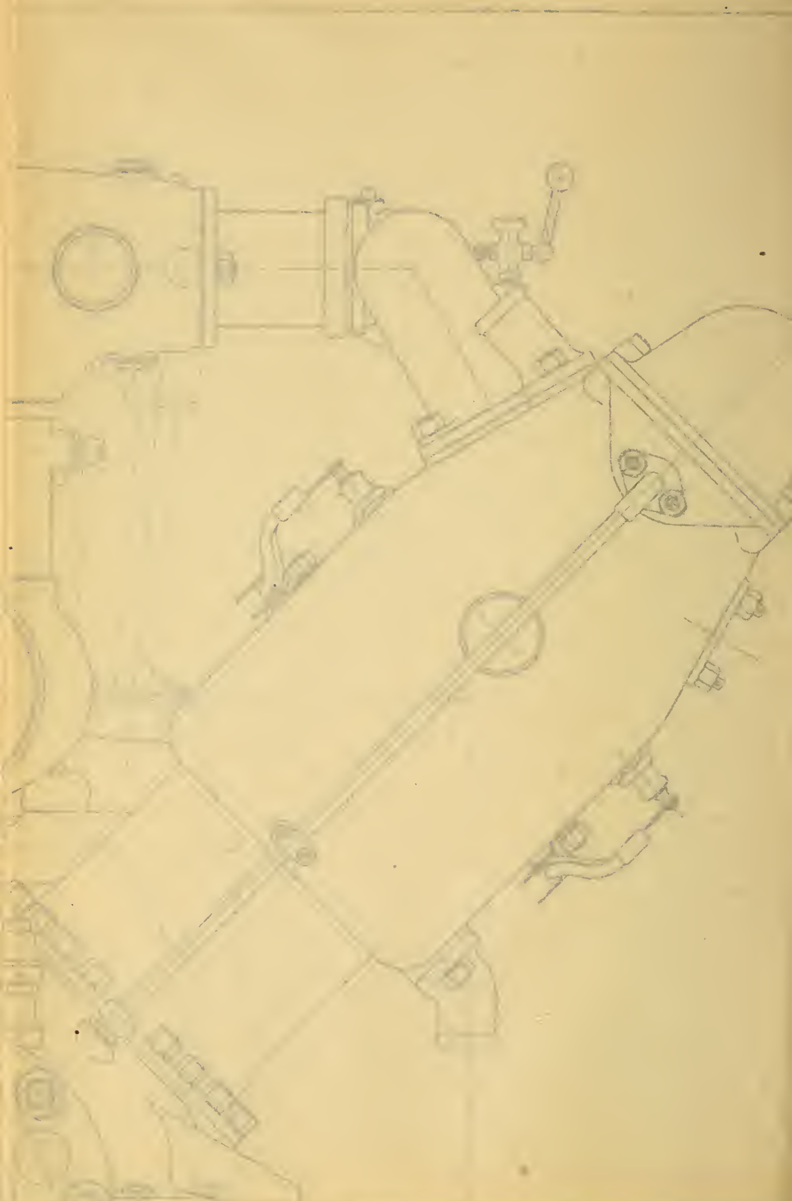


Plate 10

Installation Drawing

Approximately half size



Gasoline Supply Shut-Off.

A gasoline shut-off should be provided as near the engine as possible to enable the pilot to shut off the gasoline supply.

Placing of Water Radiators.

It is important that the plane designer place the water radiator so that there is at least a 12″ head of water above the highest part of the cylinder water space. When two side radiators are used they should be joined, if possible, by a communicating tube on top. The circulating system should have at its highest point a small expansion tank with a level cock, which avoids complete refilling of the tank. The space in the tank above the level cock should have not less than 3 litres, or 3 quarts capacity, to allow for the expansion of the water.

Water Filter.

It is indispensable to locate, in an accessible manner, a filter between the cylinder outlets and each radiator to stop sediment in the water which deposits in the jackets and tends to clog the radiators.

Precautions.

See that all water and oil connections are tight.

See that the carburetor control rods are pinned in place at both ends and that they work freely. See that they function the carburetor control levers from one extreme to the other. Always take these precautions, remember that any one of these coming loose may cause a forced landing.

PART IV

STROMBERG AIRPLANE CARBURETOR USED ON MODEL "H" 300 H. P. HISPANO-SUIZA

TYPE NA-D6

In this carburetor the fuel is metered and discharged by suction generated from, and depending upon, the rate of air delivery through the venturi tubes to the carburetor. The fuel delivery is made to respond in proper proportion to this suction by the induction of air into the jet. This keeps the mixture constant throughout the throttle range.

The compound venturi tube construction also develops a powerful suction at the point of fuel discharge and, in conjunction with the air injection, gives complete atomization.

Metering Nozzles.

For each carburetor unit there is a separate nozzle through which the whole gasoline supply for that unit is taken. These nozzles are located horizontally so that they may be changed without removing the carburetor from the engine. A similar nozzle, several sizes larger, may be used, in the accelerating well to assist atomization, but this is sufficiently large to require no change.

Idle Running.

During idle and low throttle running the gasoline, after passing through the metering nozzle, is carried up into the idle tube end, after dilution with a small quantity of air, is discharged through a slot at the edge of the throttle. The amount of air dilution governs the mixture proportion for these speeds and is controlled by the idling adjustment needle.

Accelerating Well.

Below and concentric with the main discharge nozzle is an accelerating well chamber, with a small air vent at the top which leads to the main gasoline channel at its bottom. This well chamber acts as a reserve supply of fuel for acceleration, its contents being delivered as the throttle is opened, and replenished from the main jet flow when the throttle is closed. Thus the mixture becomes, temporarily, slightly richer than normal as the throttle is opened, and temporarily thinner than normal as the throttle is closed; an action found necessary for flexible operation with low grade American gasoline.

Float Mechanism.

The float mechanism is positive in its action and hung in such a way that it will operate at angles between 45° climb and a straight dive; also under a considerable sidewise inclination. The float needle valve is pointed upward so that any dirt will wash down, away from the valve seat, and is held to its pin by a self-contained spring plunger to obviate wear under the vibration of the engine.

The needle valve point is of an especially hard non-corroding alloy and ground true while the needle valve seat is of softer material so as to follow the shape of the harder needle point.

The operation of the float mechanism during different aerial maneouvers depends not only upon gravity but also upon the motion of the airplane. Assuming that the carburetor is mounted with the air entrance to the front of the plane, the carburetor float will function normally whenever the pilot is resting on his seat, leaning heavily against the back or sides of his seat, or tending to slide forward.

When diving at a steep angle, if the throttle is closed all the way to the idling position, some fuel will drain out of the main discharge jets in the air entrance of the carburetor. This will drain away through the air-horn drain tube when the plane straightens out, but this accumulation will be avoided altogether if the throttle is kept a little further open so that there is enough draught in the venturi to carry this fuel up from the jet into the engine.

If the position or motion of the plane is such that the pilot tends to fall away from his seat, the same forces will cause the float to go *up*; this closes the float needle valve. At the same time the fuel will go to the top of the float chamber and cease to flow from the discharge jets. It will not leak from the vents in the top of the float chamber however, if the throttle is kept a little open.

NA-D6 STROMBERG CARBURETOR ADJUSTMENTS

Pilot's Control of Altitude Adjustment

The mixture proportion delivered by this carburetor is subject to little variation in passing from sea level to approximately 915 meters or 3000 feet altitude. In the "Rich" position the mixture is slightly richer than necessary. This can be corrected for more than 6100 meters or 20,000 feet altitude, by moving the altitude-control lever forward to the "Lean" position. The control should always be placed in the leanest position that will give maximum r.p.m. of the engine, thus giving maximum torque.

The metering nozzles above referred to are graded and numbered according to the common industrial Twist Drill and Steel Wire Gauges.

This control of the mixture is obtained by the rotation of the sleeve in the pilot's control, which opens to a greater or lesser extent, or closes off entirely, the communication between the float chamber space and the holes drilled in the upper part of the large venturi tube. The float chamber has also a smaller atmospheric vent hole communicating through a gauze strainer with the interior of the air entrance of the carburetor. When the connection to the venturi tubes is full open, a considerable suction is communicated to the float chamber and this suction opposes the suction at the main discharge nozzle, thereby reducing the gasoline flow through the metering nozzle.

When the passage between the venturi and float chamber is shut off entirely, atmospheric pressure exists in the float chamber and the maximum gasoline delivery is obtained.

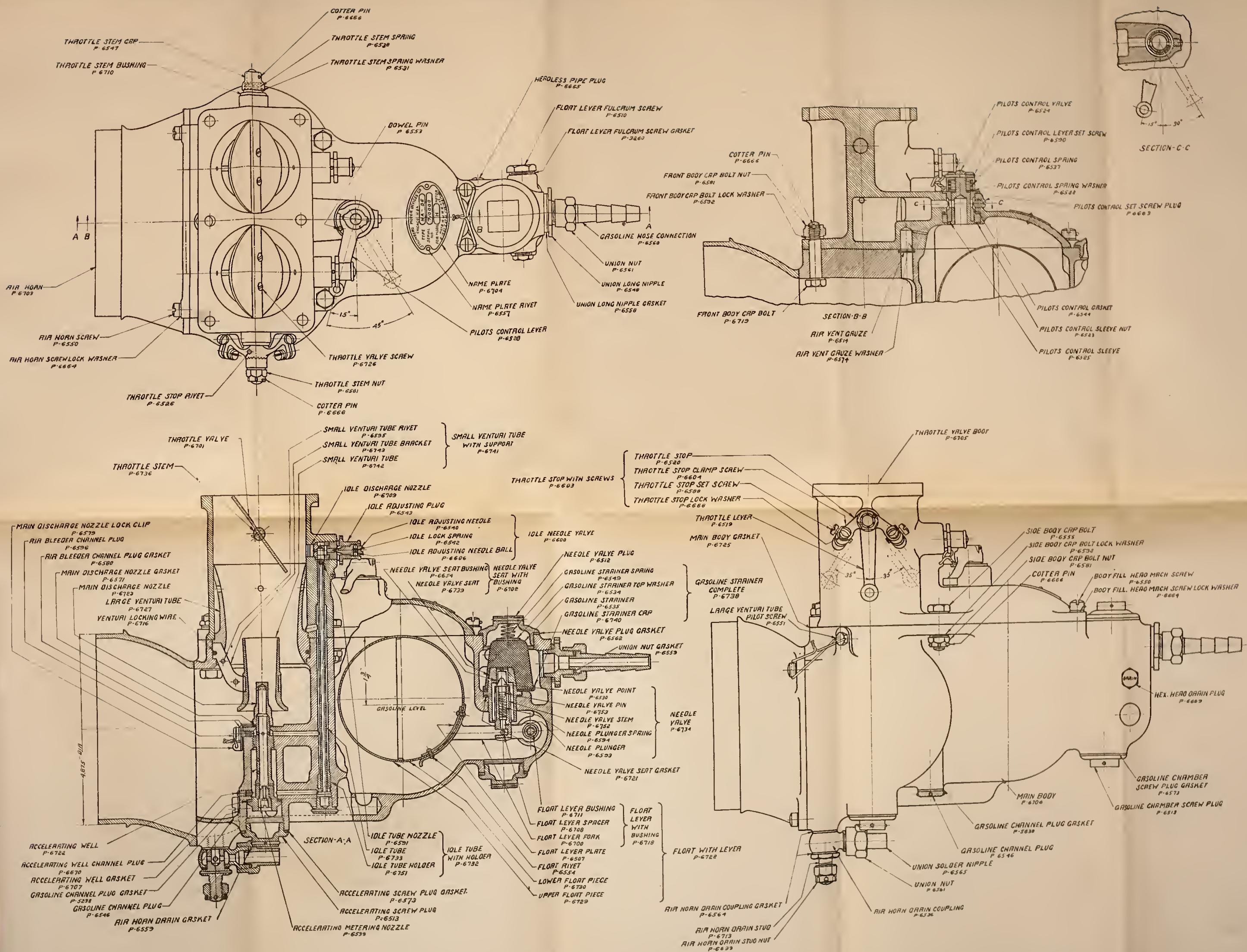


Plate 11

Stromberg Carburetor (Vertical Type NA-D6) Cross Section View

Approximately half size

With the venturi suction channel partially opened the gasoline flow is correspondingly reduced.

Since a strong suction exists in the float chamber when the control is in the lean position, care should be taken that the joint between the upper and lower halves of the carburetor is *kept tight,* and that the gasoline channel plugs in the lower part of the carburetor are drawn tight on their gaskets. If these leak sufficiently to allow gasoline to drip, they will also permit air to be drawn in with the flowing gasoline, which will interfere somewhat with the mixture regulation.

Idle Adjustment.

The idle adjustment needle affects the low speed only and has practically no effect on the high-speed action. Screwing the needle inward, right hand, gives less air dilution and more gasoline to the mixture "Rich;" left hand, less gasoline, "Lean." An average adjustment is obtained when the idle adjustment needle is unscrewed about one complete turn from a seating position; an exact adjustment is made at the factory when the engine is tested and need be changed only under extreme weather conditions.

DISASSEMBLY AND REPAIR OF STROMBERG NA-D6 CARBURETOR

The Strainer.

Most caburetor trouble arises from the presence of small particles of dirt. The best preventative is to keep the strainer and strainer chamber clean. After ten hours' running, and before every important flight the strainer should be cleaned and the strainer chamber drained by taking out the plug so marked. Plates 11 or 12.

Carburetor Leaking or "Flooding."

If leaking or "flooding" occurs, a careful inspection should first be made to see whether the leakage is due to some plug below the normal gasoline level of the carburetor being loose on its gasket; or whether the float valve is insecurely seated, allowing the level to rise so that the gasoline overflows from the main discharge jets. In the latter case the strainer chamber should be inspected and drained to remove any dirt, and carburetor flushed to wash out any particles on the needle valve seat. It may also help to remove the plug beneath the float valve and, with a screw-driver, rotate the needle valve within the limits permitted, while pressing it up lightly against the seat. If flooding persists it will be necessary to remove the carburetor from the engine and substitute a new needle valve or seat, or both, as required. See that the float is not punctured and does not contain any gasoline. The level as determined by the float action, should be approximately 45 m/m or 1¾″ below the junction of the halves of the carburetor.

To Remove Float Needle Valve.

Take out float lever fulcrum screw and move float forward sufficiently to allow the needle to drop down. To remove the float needle seat it is first necessary to remove the float. Then loosen the set screw which goes in from the side of the carburetor, and unscrew needle seat with a large screw-driver. NOTE that in replacing fulcrum screw a 1 m/m or $\frac{1}{32}$″ "thick" hard gasket must be used under the head, as otherwise the pin will screw in far enough to clamp the float pivot bearing.

When carburetor halves are separated care should be taken that the joint surfaces are not nicked or marred, and when assembled a dry paper or composition gasket of even thickness should be used.

To Remove Venturi Tubes.

To change venturis, take out the three bolts and two cap screws holding the halves of the body together, loosen the set screws, holding the venturis about one turn, but do not remove them at this time. Separate the halves of the body carefully so as not to bend the two idling tubes, remove set screws and take out venturis.

In replacing the venturis, be sure that the hole for the venturi pivot screw registers correctly, and that the screw point enters the gap of the locking ring. While the carburetor is disassembled be careful that the surface of the joint is not marred, and when assembled be sure that gasket joint between halves is tight and secure.

In changing venturis the throttles should not be disturbed as it might be difficult to replace them properly. The venturis are numbered according to the smallest inside diameter in inches.

Metering Nozzles.

The accelerating metering nozzles are located in the accelerating well. To remove these it is necessary to remove the carburetor from the engine. Remove accelerating screw plugs; unscrew the accelerating metering nozzle, using a screw-driver which is a close fit in the slot to avoid marring the nozzle which might effect the fuel discharge.

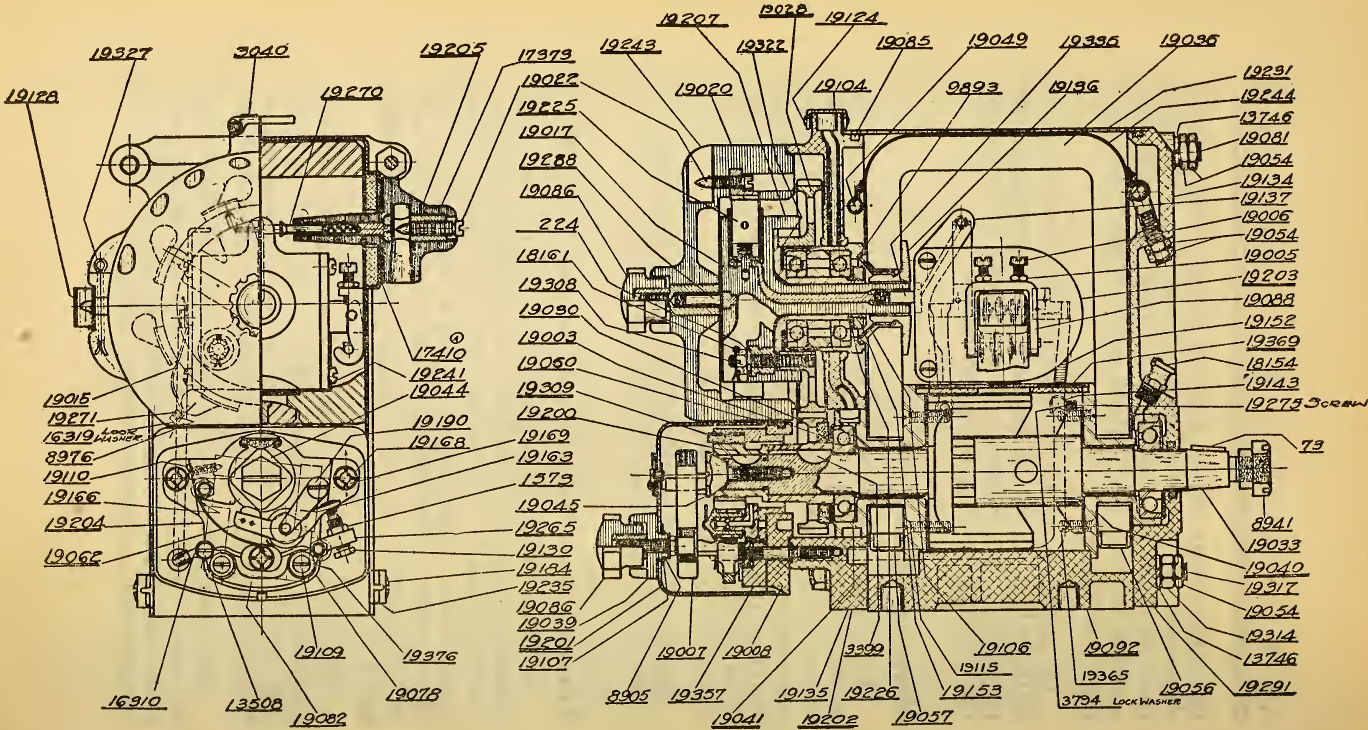
Be sure that the accelerating screw plugs are replaced tight on the gaskets so that there is no leak.

Throttle and Altitude Adjustment Controls.

On Plate 11 it will be found that the throttle lever moves through 70° from closed to wide-open position. The lever has a 1⅞″ radius from the center of the throttle lever stem to the center of the hole in the throttle lever. The altitude adjustment moves through 45° from closed to wide-open position and the lever has a 1⅞″ radius from center to center.

The carburetor is so mounted that all of the control connections are made from the rear end of the engine. The installation is such that motion longitudinal to the crankshaft of the engine is required to operate them.

Each control should be provided with a ratchet working over a toothed sector to hold it in any desired position. All controls should work freely and, at the same time, permit a minimum of lost motion.



FOR L.H ROTATION

Plate 13

PART V

IGNITION SYSTEM

General Description.

Ignition is furnished by two eight-cylinder magnetos firing two spark plugs per cylinder.

These are mounted at the rear of the crankcase and driven at crankshaft speed. The right-hand magneto runs anti-clockwise and the left-hand runs clockwise.

THE DIXIE TYPE 800 MAGNETO

The Dixie magneto is of the inductor type, the rotating member consisting of two pieces of magnetic material separated by a non-magnetic centerpiece. The coil is mounted stationary in the arch of the magnets. This rotating member constitutes true rotating poles for the magneto and rotates in a field structure, composed of three laminated field pieces.

The bearings for the rotating poles are mounted in steel housings which lie against the poles of the magnets.

When the magnet poles rotate, the magnetic lines of force from each magnet pole are carried directly to the field pieces. There are no losses by flux reversal in the rotating poles, neither are there any revolving windings on the rotor.

With the dust and water protecting casing removed, the winding can be seen with its core resting on the field pole pieces and the primary lead attached to its side.

An important feature of the high tension winding is that the heads are of insulating material, and there is not the tendency for the high tension current to jump to the side as in the ordinary armature type magneto.

The high tension current is carried to the distributor by means of a brass rod which is molded in the distributor rotor, at one end of which is a spring brush bearing directly on a plate in the end of the coil.

The condensor is placed directly in front of the breaker and is instantly removable by taking off the breaker cover and removing the two nuts which hold it in place.

The high tension current is generated in the winding housed in the arch of the magnets, without the use of a special induction coil. Four sparks are produced during each revolution of the rotor.

Care of the Dixie Type 800 Magneto.

The bearings of the magneto are provided with oil cups which should be oiled with a few drops of oil every twenty-five hours of engine running. The breaker lever should be lubricated every twenty-five hours of engine running with a few drops of oil applied with a tooth-pick. Three-In-One oil should be used for all the above lubricating.

The proper distance between the platinum points when separated should not exceed .5 m/m or .020″ or 1/50 of an inch. A gauge of the proper thickness is attached to the wrench furnished with the magneto spare parts equipment.

The platinum contacts should be kept clean and properly adjusted. Should the contacts become pitted, a fine file should be used to smooth them in order to permit them to come into perfect contact. Do not file any more than is absolutely necessary.

The distributor block should be removed occasionally and inspected for carbon dust. The inside of the distributor block should be cleaned every five hours of engine running or before each important flight with a cloth moistened with Three-In-One oil (never use gasoline), and wiped dry with a clean cloth. When replacing the block, care must be exercised in pushing the carbon brush into the socket.

The magneto should not be tested unless it is completely assembled, that is, with the breaker-box, distributor cover, and wires in position.

Whenever the wires leading from the magneto to the spark plugs are taken off, observe that they are correctly replaced in relation to the firing order of the engine, which is 1L-4R-3L-2R-4L-1R-2L-3R.

Do not pull out the carbon brush in the distributor because you think there is not enough tension on the small spring.

Do not forget that the magneto will always work best with the spark plug gap set at .5 m/m or .020″. These should be checked before each important flight or about every 10 hours of running.

Timing or Setting the Magnetos.

In order to obtain the utmost efficiency from the engine, the magneto must be correctly timed to it in the following manner: The timing of the magnetos is accomplished with the aid of the timing disc which is first located by the top center of cylinder 1-L and the right-hand magneto is then put in place to fire cylinder 1-L. Next the left-hand magneto is set to fire cylinder 1-L also and the two magnetos then synchronized so that they fire at the same time.

To set the magnetos, place the timing disc in position and locate the top center on the disc as noted under "Finding top center and setting the timing disc." Part IX. After the disc is set, turn the engine over until No. 1-L cylinder is on the firing stroke and line "M.A. 1 and 4 Left" on the disc is at zero 78½ m/m or 25° before the top center.

The firing stroke may be ascertained by either one of the following methods:

I. Observing whether the exhaust valve is open on top center. If the valve is not open, the engine is on the firing stroke. If the valve covers are not removed put a finger on the valve through the exhaust port as the engine is turned over which will enable the position of the valve to be determined.

II. By placing a finger or dead center indicator as illustrated in Plate 26 in the spark plug hole, proceed to turn the engine in the direction it rotates until you begin to feel the pressure coming against this finger.

Then watch the timing disc, still turning the engine in the direction of rotation, until the line "M.A. 1 and 4 Left" on the disc coincides with zero on the scale. See Plate 26.

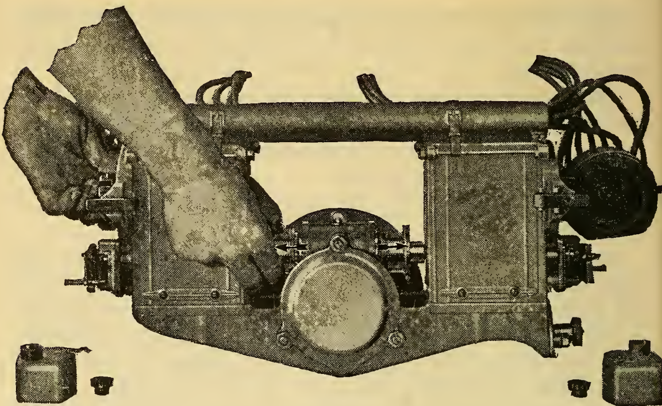
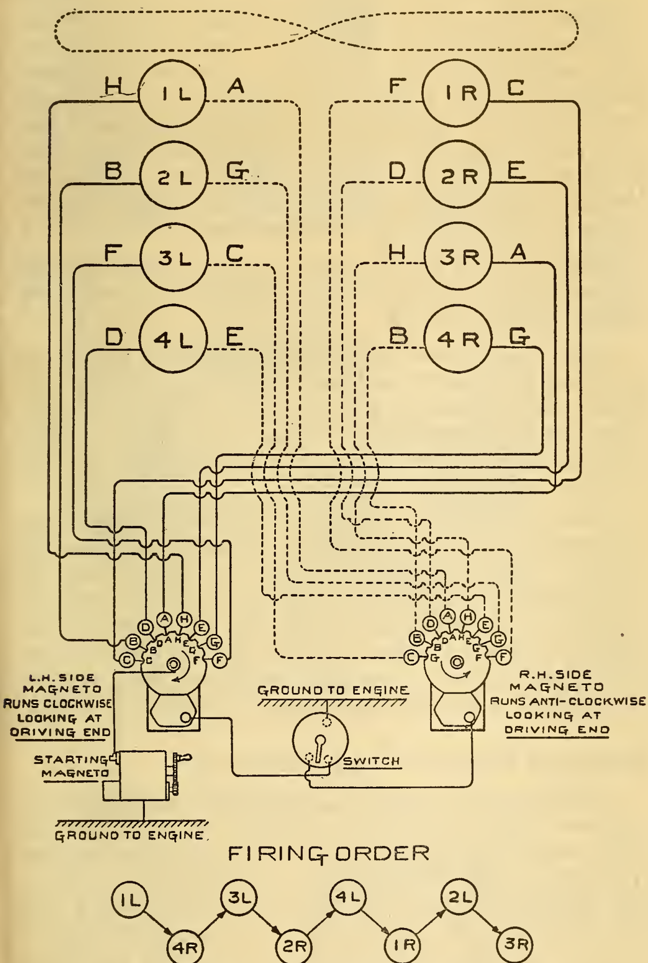


Plate 14
Timing the magneto to the engine.

Remove the distributor and breaker covers of the magnetos, and put the right-hand magneto in place with the distributor brush on No. 1-L segment with the breaker points just commencing to open, or as nearly as is possible with the tooth engagement. See Plate 14. Fasten the magneto in place with two of the four cap screws and turn the engine back one-eighth of a turn. Next, turn the engine slowly in the direction of rotation until a cigarette paper placed between the breaker points just draws, and note the position of the line "M.A. 1 and 4 Left" on the disc with respect to zero. If the paper does not draw with the line directly under zero adjust the magneto coupling until the paper will just draw.

This adjustment is made by removing the cotter pin that goes through the coupling and sliding the coupling towards the magneto, rotating the magneto armature by means of the distributor gear whatever amount is necessary. Then let the coupling come back in place. Always turn the engine back one-eighth of a turn and then in the direction of rotation to remove all the backlash in the magneto driving gears, illustrated in Plate 14.



WIRING DIAGRAM OF
DIXIE 800 MAGNETOS
WITH CROSS DRIVE MAGNETO MOUNTING

Plate 15

After setting the right-hand magneto, put on the left-hand one and with line "M.A. 1 and 4 Left" still at zero, adjust in the same manner as for the right-hand magneto. When both magnetos are set, place paper between the breaker points of both and turn the engine slowly in the direction of rotation until both papers can be drawn. If they do not draw simultaneously re-adjust the left-hand magneto coupling until its paper draws at the same time as the right-hand one.

Fasten both magnetos down securely with four cap screws apiece. Replace the cotter pins through the center of the couplings.

Check the breaker point openings by the aid of the gauge on the wrench and set, if necessary, so that the points when wide open are .5 m/m or .020″ apart. Replace the distributor and breaker covers, being careful to have the distributor brush in position and the distributor path clean.

When a change of magnetos is required, those for replacement may be timed from those already on the engine. Turn the engine over until No. 1-L is ready to fire, then remove the left-hand magneto and put the new magneto in place with the distributor brush on No. 1-L segment and adjust the coupling until the paper draws at the same time as the right-hand one, then remove the right-hand magneto and repeat the above operation.

Wiring of Magnetos and Cylinders.

It will be noted that all the spark plugs located on the intake or inside side of the cylinders are wired to the R.H. magneto while the plugs on the exhaust or outside are wired to the L.H. magneto. If there is any misfiring, this arrangement makes it very easy to find which side has the bad spark plugs by cutting one magneto at a time out of operation. If one or the other magnetos are cut out while the engine is running, the number of revolutions of the engine lost should be the same (about 20 r. p. m.).

The firing order of the engine is 1L-4R-3L-2R-4L-1R-2L-3R.

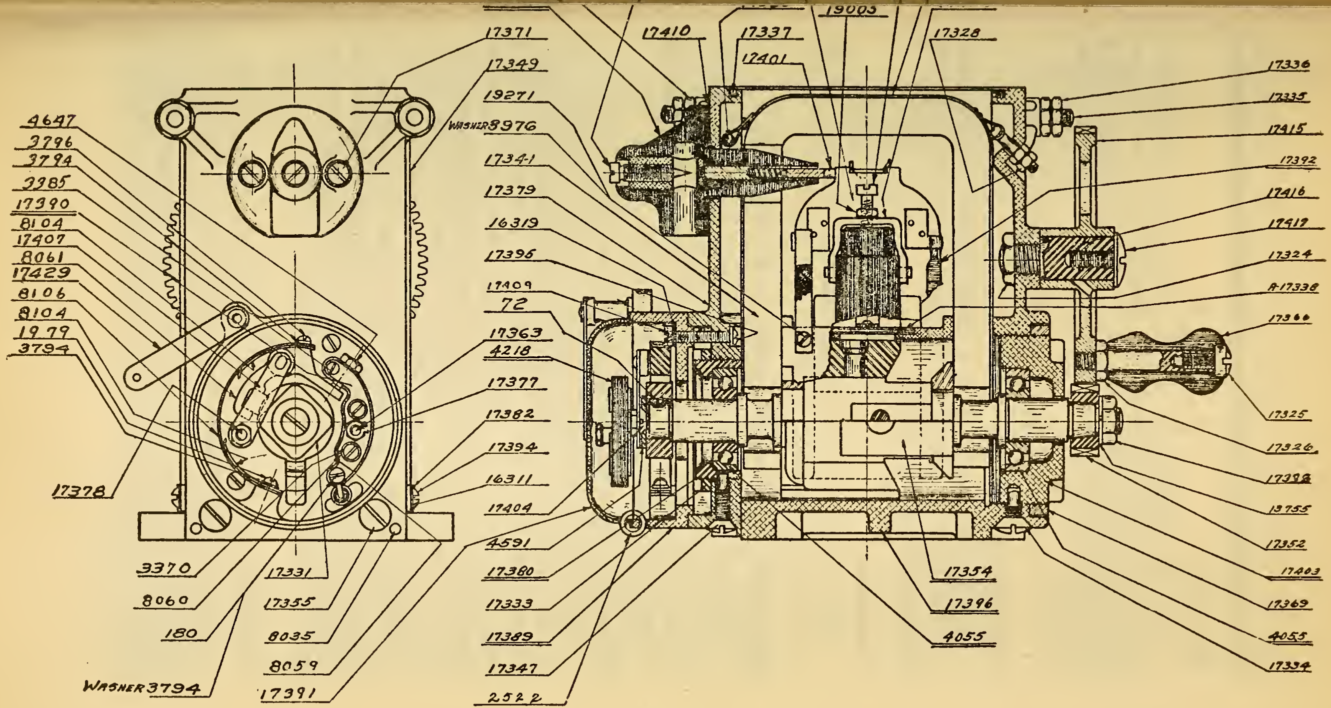


Plate 16

Dixie starting magneto. End and side-view section.

Caution.

Do not attempt to crank an engine immediately after it has been stopped. An over-heated spark plug or red-hot piece of carbon might cause pre-ignition and a disastrous back-kick. Always allow it to cool a few minutes.

STARTING MAGNETO

Description.

The starting magneto is a small magneto of the same construction as the larger magnetos and is used only when starting the engine.

Location.

This magneto is generally mounted in the cockpit of the plane, in easy access of the pilot.

How the Starting Magneto is Connected.

One side of the starting magneto is connected to the brush in the center of the distributor on one of the running magnetos. The other side is grounded to the engine to complete the circuit. Plate 15.

How the Starting Magneto Operates.

The engine is primed through the pet cocks on the intake manifolds and turned over compression on about three cylinders, by the propeller. The man turning the engine over stands aside and the pilot puts the ignition switch on and turns the starting magneto by hand. This throws a shower of sparks into one of the running magnetos and is transmitted to the spark plug of the particular cylinder the engine happens to be stopped upon. This shower of sparks will start the engine, providing the mixture is correct in the cylinders and all other things properly set.

Caution.

A starting magneto will always give a spark when turned regardless of the switch position or running magneto position. Never turn the starting magneto until the man cranking the engine stands away from the propeller.

PART VI

LUBRICATING SYSTEM

We recommend a good mineral oil with the following characteristics:

Flash Point (Open Cup)	465° F. Minimum
Burning Point	520° F.
Viscosity (Saybolt)	107—112 at 210° F.
(Tagliabue)	110—115 at 212° F.
Specific Gravity	.8860
Cold Test	4.5 or 40° F. Maximum
Carbon Residue	
Emulsion Test	

Oil Temperature.

The temperature of the oil should be held, even in the hottest weather, below 93° C. or 200° F. under all conditions, and is best not to exceed 71° C or 160° F.

Description of Oiling System.

The oiling of the engine itself is provided for by a positive pressure system. A gear type of pump being mounted in the rear of the crankcase. It is driven at crankshaft speed, by the same bevel gear on the crankshaft that drives the vertical shafts.

In order to keep the oil sump dry and to assist circulating the oil through the oil radiator and reserve oil tank, there are two additional oil pumps of the gear type. These are also located in the lower half of the crankcase at the rear end and driven at crankshaft speed from the same bevel gear on the crankshaft that drives the vertical shafts. Plates 20, 22 and 23 show these oil pumps and the method by which they are driven.

Lubrication Circulation in the Engine.

The oil pressure pump takes the oil from the oil tank and forces it through a filter provided with a removable screen. The filter is located in the lower half of the crankcase just in front of the gear oil pumps. The oil

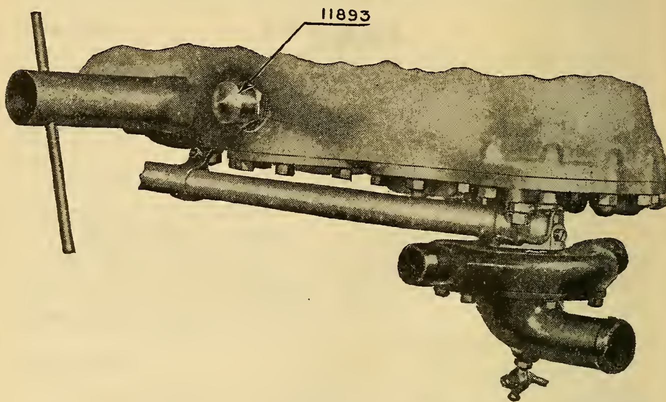


Plate 17

Showing how to remove the oil pressure relief valve body.

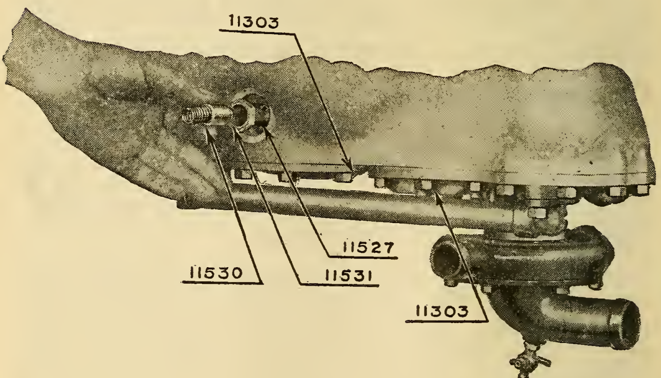


Plate 18

Removing oil pressure relief valve plunger

after passing through the oil filter is forced through steel tubes which are cast in the lower half of the crankcase to three of the main bearings.

From these bearings the oil enters the hollow crankshaft and is distributed to the four crankpins; proper oil holes being provided in the inner connecting rods to distribute the oil to the outer connecting rods. The oil is then thrown off of the crankpins or crankshaft

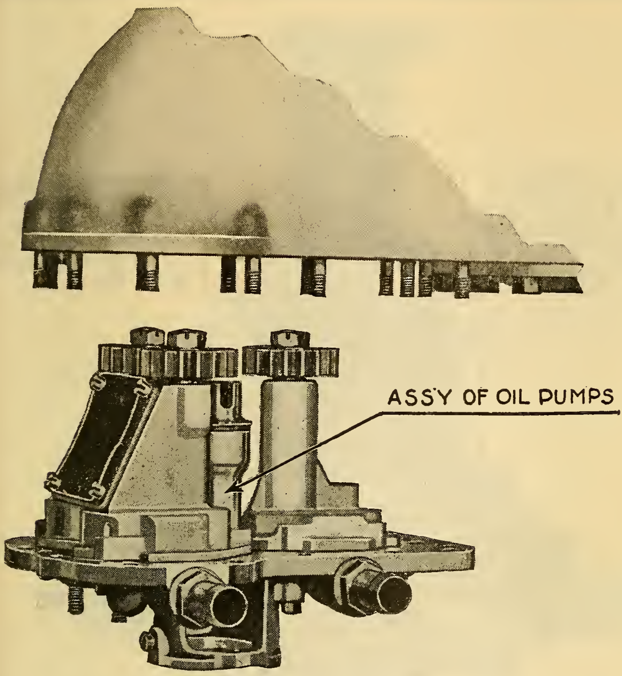


Plate 20

Removing oil pumps assembly from the lower crankcase.

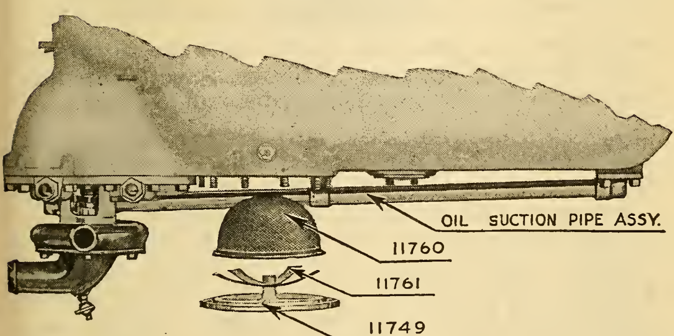


Plate 21

Removing oil strainer assembly from the lower crankcase.

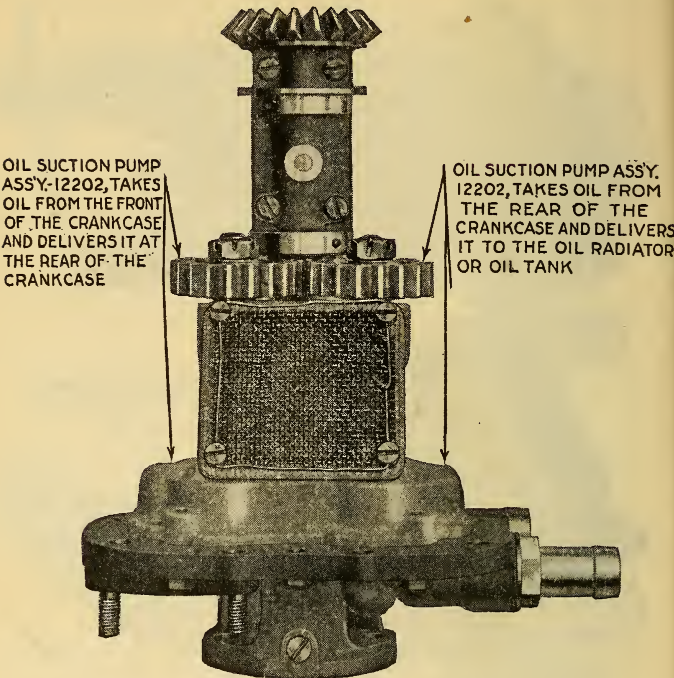


Plate 22

Rear view of oil pumps assembly and gear pump drive pinion.

in the form of a spray and together with the oil thrown from the main bearings by the crankshaft, provides lubrication for the cylinders, pistons and piston pins.

The fourth or front main bearing has a by-pass and is also provided with an oil lead from the system, which takes care of the lubrication of this bearing. Through a by-pass around the outside of the bearing the oil leads to tubes running up the front end of each cylinder block. This provides lubrication for the camshafts, camshaft bearings, valve tappets, valve stems, vertical shafts, vertical shaft bearings and driving gears. As the camshafts are hollow, the oil is forced into them at the front end through the camshaft bearings.

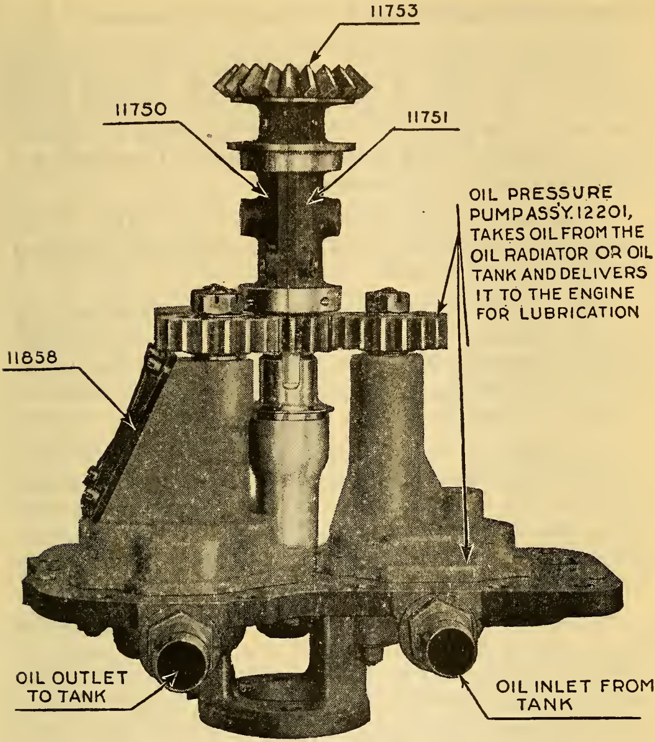


Plate 23

Right side of oil pumps assembly and gear pump drive pinion.

Lubrication of the cams, valve tappets and valve stems is provided for by small holes in each cam, and of the remaining camshaft bearings by other small holes in the camshaft.

The excess oil escapes through the other end of the camshafts in the form of a stream and, together with the oil remaining in the cylinder covers, oils the vertical shaft bearings and the driving gears before it is returned to the crankcase through the vertical shaft casing at the rear of the engine. See "Oil Circulating System," Plate 00.

How to Connect the Lubrication System.

The lubrication system can be connected as shown in Plate 19. This system is known as the dry-sump system. The only oil in the lower half of the crank-case when the engine is running is that held in suspension. There is no oil in the lower half of the crankcase when the engine is *not* running.

If the oiling system is connected as in Plate 19; the following is the manner in which the engine is lubricated and the oil circulated:

Sufficient oil is kept in the system by keeping the oil tank filled. The oil tank can be located in the pilot's or observer's cockpit, although it does not necessarily have to be so located. If sufficient room is available it can be located somewhere near the engine.

The filling of the oil tank is done through a filler cap located on its top. The oil is taken from the bottom center of the oil tank by the oil pressure pump located in the rear of the lower half of the crankcase, a strainer being placed over the exposed end of the pipe to keep any foreign matter from going into the oil pump.

One of the oil suction pumps removes the oil from the front part of the lower half of the crankcase and delivers it at the rear of the crankcase, while the other suction pump removes this oil and any other oil that has collected at the rear of the lower half of the crank-case and delivers it to the oil tank. It will be seen that this method of circulating the oil will keep the oil sump dry under climbing and driving or any other operating conditions under which the engine is required to operate in the air.

The circulation of the oil from the oil tank and through the engine has just been described under "Lubrication Circulation in the Engine."

Oil Radiator.

The oil radiator should be made of thin section not over one inch in thickness, with very thin ribbed sections.

At the connections where the oil enters and leaves the oil radiator, there should be raised places in the tank in order to give the oil a chance to spread over the complete radiator and again get back into the exit pipe without getting excessive pressure in the tank.

Aside from the thickness, the other dimensions of the oil radiator can be of any size, sufficient for cooling the oil, and suitable to the plane manufacturer.

Always remember the temperature of the oil even in the hottest weather, should never exceed 93° C or 200° F and is still better if it does not exceed 71° C or 160° F.

The oil radiator should be so placed on a plane that a draught of air strikes it, thus cooling the oil.

Oil Consumption.

Before each flight, be sure of the level of the oil in the oil tank.

Always allow 4¾ litres (about 5 quarts) of oil for every hour the engine is run wide open.

Oil Pressure Relief Valve.

Each engine is equipped with an oil pressure relief valve which is located on the left-hand side of the lower half of the crankcase at the center of the engine. This is made non-adjustable, as will be seen by Plate 18. The spring length is made so that the plunger 11531 will release the oil at from 60 to 85 lbs. per square inch pressure with an oil temperature of 150° F.

It is sometimes found that some foreign substance may get under the seat of the oil valve and the oil pressure will drop. The valve can be removed and cleaned by removing the oil pressure body 11893. See Plates 17 and 18.

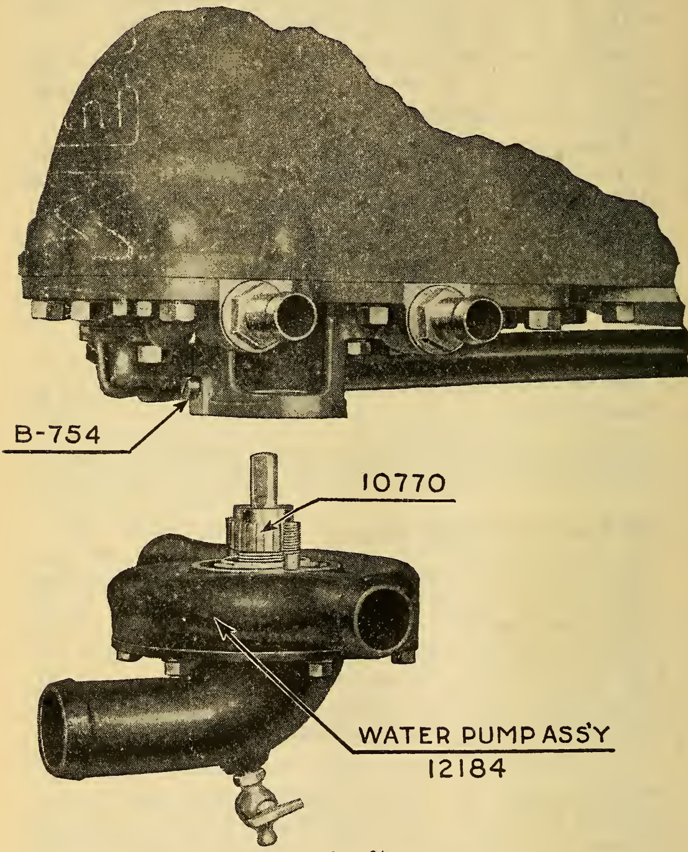


Plate 24

Water pump assembly removed from lower crankcase.

PART VII

WATER CIRCULATING SYSTEM

Kind of Water Pump.

Water circulation is provided for by a centrifugal pump with two discharge outlets mounted directly below the oil pumps and driven from its shaft at 1.20 engine speed. A rubber hose runs from each outlet to each of the cylinder blocks, the water entering each block at one end and escaping at the opposite. See Plates 5 and 8.

Capacity of Water Pump.

The water pump handles 134 litres (35.50 gallons) of water per minute at 1800 r. p. m. of the engine.

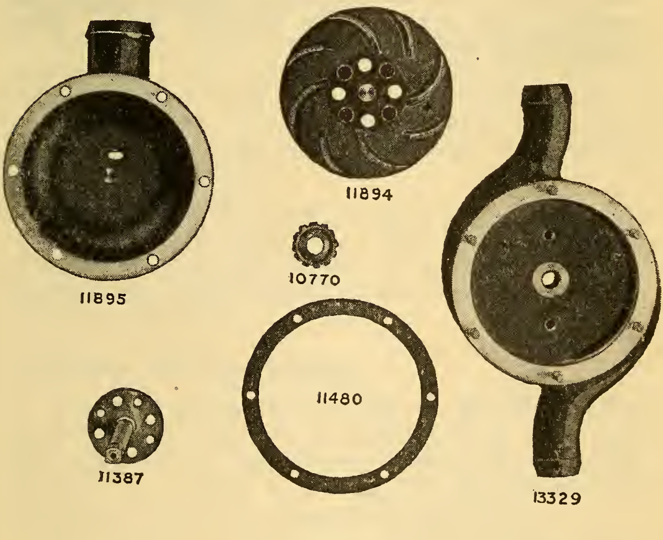


Plate 25

Water pump disassembled.

Water Temperatures.

The desirable temperature of the water outlet is 43° C or 110° F and the inlet water 10° C or 20° F lower to obtain the best engine efficiency. It may sometimes happen that for short durations or in a very hot climate the outlet temperature may rise to 88° C or 190° F.

Capacity of Cylinder Water Jackets.

The capacity of the cylinder water jackets is (25 Kilograms) 55 lbs. or about 6.6 gallons (24.8 litres).

Water Radiator.

The capacity of the radiator varies with the different radiators, but the front area should be sufficient to maintain the above water temperatures. The radiator should be fitted with adjustable shutters or an equivalent method of maintaining these temperatures in cold weather or at high altitudes, especially while taking long glides or nose dives.

PART VIII

GASOLINE SYSTEM

Kind of Gasoline to Use.

Gasoline of about 58° Baumé is recommended.

Location of Gasoline Tank for Gravity Feed.

The Gasoline tank may be placed in any convenient location but, if gravity feed is used, should be so arranged to give 1 to 2 pounds head at the carburetor for any position of the machine in flight.

Caution—Filling the Gasoline Tank.

In filling the tank always pour the gasoline through a chamois skin to free it from water and other impurities.

Gasoline Pressure System.

If an air pressure pump is used to keep pressure on the gasoline, a relief valve should be placed in the line in order to maintain a pressure of not over 2 lbs. at the carburetor. The relief valve should be designed so that it can be adjusted during flight to correct for difference in altitude.

When a pressure system is used, always make sure there is pressure in the tank before trying to start the engine. This initial pressure is obtained by a hand pump, there being a gauge on the dash to register the amount of pressure.

Gasoline Vacuum System.

A vacuum system may be used to draw the gasoline from the main tank to an auxiliary tank. The gasoline feeding from the auxiliary tank to the carburetor. by gravity. For the location of the gravity feed tank, follow the instruction above under that topic.

The vacuum is generally derived by placing a compound venturi in the draught of the propeller and taking a lead from its throat to the main gasoline tank. Always of course placing a check valve in the line and having a branch line going to the auxiliary gasoline tank.

Installation of Gasoline Line.

The gasoline line from the tank to the carburetor may be of copper tubing, but should have a rubber hose connection at the carburetor of at least 12 inches in length. This is a necessary precaution to prevent the vibration and weaving of the plane from crystalizing and breaking the copper tubing.

Size of Gasoline Line.

The gasoline line should be of sufficient size to allow 189 litres or 50 gallons of gasoline under 2 lbs. pressure or 4 foot head, to flow through it in one hour.

MEMORANDUM

PART IX

VALVE TIMING

	Length of arc taken in diameters of 360 m/m (14.17″)	200 m/m (7.87″)*	Crankshaft Timing in Degrees
Intake opens before top center	32 m/m (1.25″)	18 m/m (.708″)	10°
Intake closes after bottom center	194 m/m (7.63″)	108 m/m (4.25″)	62°
Exhaust opens before bottom center	196 m/m (7.71″)	109 m/m (4.29″)	62½°
Exhaust closes after top center	92 m/m (3.62″)	51 m/m (2.00″)	29½°
Spark advance before top center	78 m/m (3.07″)	43 m/m (1.69″)	25°

*200 m/m (7.87″) is the diameter of the propeller hub flange.

Valve Timing.

The timing of a Hispano-Suiza engine may be subdivided into four separate and distinct operations. The first step is to attach the timing disc and set it to correspond with the top center of Cylinder No. 1 Left. The second step is to time or set the camshafts themselves. The third to set the valve tappet clearance. The fourth to check the timing of the valves. The left-hand camshaft is set first, by the opening of the inlet valve in Cylinder No. 1, the engine then turned a quarter turn in the direction of rotation and the right-hand camshaft set by the opening of the inlet in Cylinder No. 4.

If no timing disc is available for the first operation, the timing in Plate 27 can be duplicated on a piece of sheet-metal or card-board 360 m/m in diameter from the above table. Remove the propeller from the hub and place this disc in position against the flange and replace the propeller. A scale should be made of sheet-metal and fastened under the vent plugs as shown. Plate 26. This table also gives the timing in m/m for the propeller hub diameter and in degrees for whatever diameter disc that might be used on the crankshaft.

I. Preparations for Timing the Engine.

Place the timing disc and hub on the propeller hub taper, lock it in place with hub nut and attach the indicating scale as shown in Plate 26.

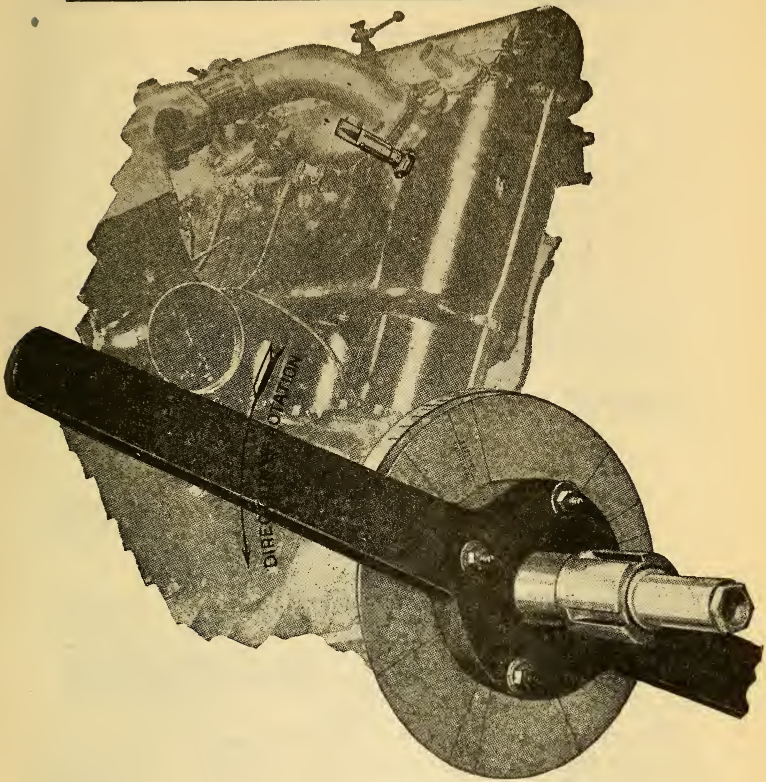


Plate 26
Finding top center.

Finding Top Center and Setting the Timing Disc.

Remove all the outside spark plugs, which allows the engine to be readily turned over by hand, and with the timing disc in position turn the engine slowly in the direction of rotation until the piston in Cylinder No. 1-L is on top center. This may be ascertained by placing the little finger or dead center indicator through the spark-plug hole and observing when the piston just ceases to move upward. Plate 26. With the piston on top center, loosen the locking nuts holding the disc,

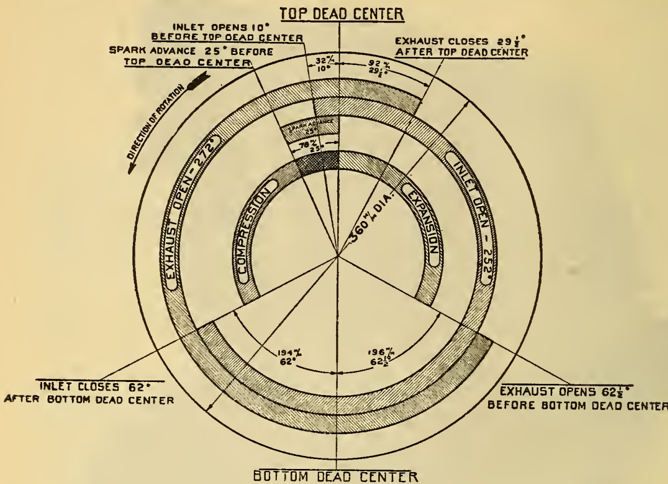


Plate 27

Valve and magneto timing.

rotate the disc on the propeller hub (the holes holding it to the propeller hub being slotted), until the line marked "T. C. 1 and 4 Left" is directly under zero on the scale, then lock the disc in position. See Plates 26 and 27.

The more accurate method of determining top center is by the use of the top center indicator which fits in the spark-plug hole having an indicator which gives the location of the piston. This can be furnished by the Wright-Martin Aircraft Corporation as shown in Plate 26.

You are now sure that when the mark "T. C., 1 and 4 Left" on the timing disc is brought to the center of the scale, which is fastened on the vent plug, that the piston on No. 1 left cylinder is at top center.

II. Timing or Setting the Camshaft.

After the engine has been reassembled it is necessary to set or retime the camshaft. Turn the engine,

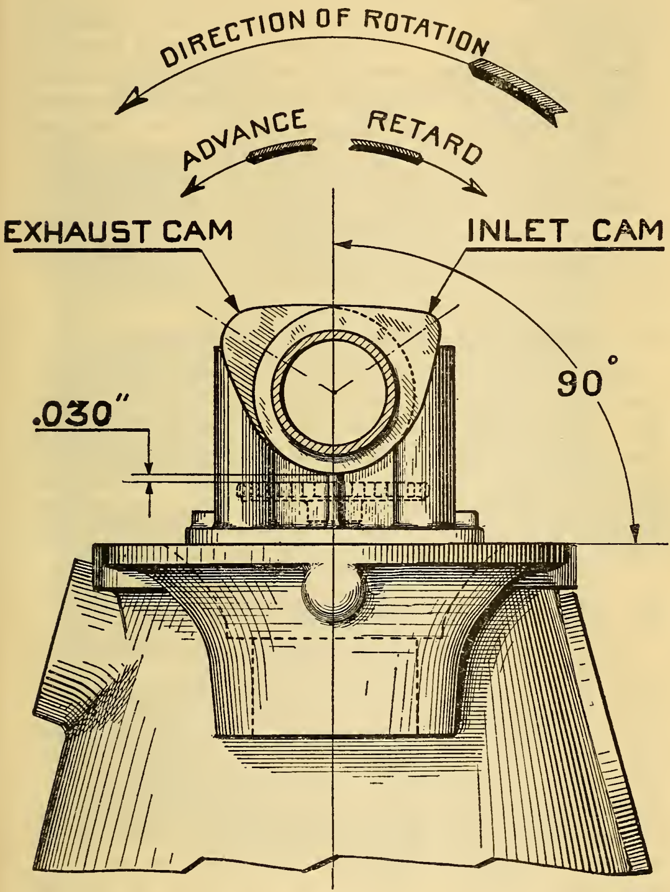


Plate 28

Position of cams when piston is 32 m/m on 360 m/m disc or 10° past top firing center.

always, in the direction it runs, by the club on the timing disc. The engine being on top center on No. 1 left continue to turn the engine until the disc is 32 m/m past center or 10°, this is the position of the crankshaft when the valves are in the position as shown in Plate 28. The camshaft can now be mounted, when the engine crankshaft is in this position. In putting the camshaft in place with its gear attached, place it so that the top faces of the cams are parallel in relation to the valve tappets of cylinder 1-L, that is the noses of the cams pointing upward. Plate 28. Tighten the six nuts A-T-948-A on the three camshaft bearings securely as a slight looseness will cause a considerable variation in timing.

III. Setting the Valve Tappet Clearance.

Adjust the clearance between the back of the cams and the valve tappets A-9615-B to .030″. See Plate 28. The clearance is readily set by the aid of wrench No. 12028, which is to be found in the tool box. The wrench fits into holes in the edge of both the tappets and their locking washers. This wrench allows the tappets to be screwed up or down in their respective valve stems, thus varying the clearances.

IV. Checking the Timing of the Valves.

Bring the timing disc slowly backward, turning the crankshaft in the opposite direction from which it runs, place a cigarette paper between the inlet and exhaust cams and their respective tappets, then gently rotate the engine forward (or in the direction it runs), feeling the paper under the inlet cam which should begin to tighten (inlet valve open) 32 m/m or 10° before top center while the paper under the exhaust cam should free (exhaust valve close) 92 m/m or 29½° after the top dead center. If the paper under the exhaust cam does not free until the disc is 15 m/m or 4.7° after top center it is said to close early.

If it does not free until the disc is 125.6 m/m or 40° after top center it is said to close late.

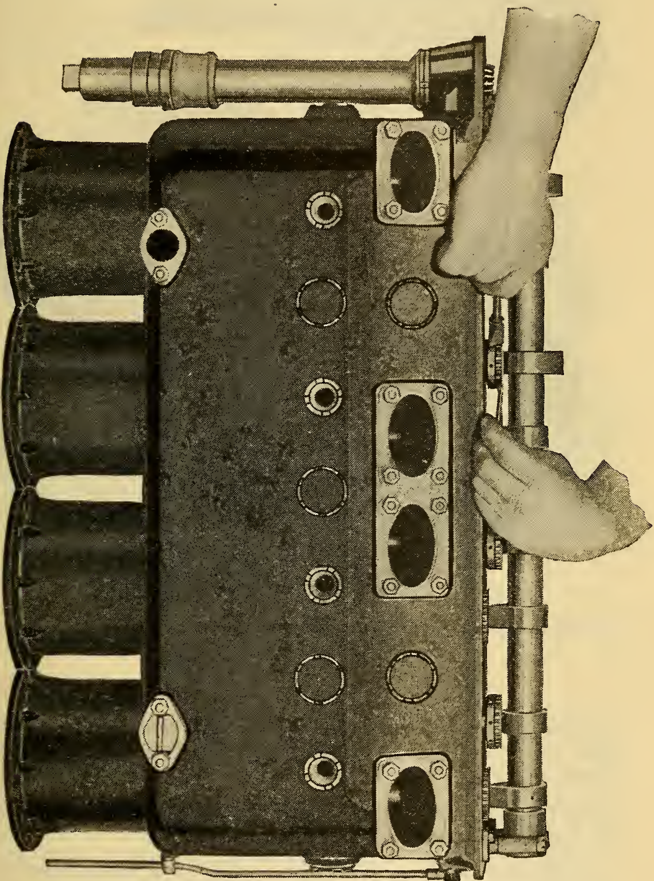


Plate 29
Adjusting the valve tappet clearance.

Plate 30

Raising or lowering vertical shaft casing in order to raise the vertical shaft and bearing for timing.

If the paper under the inlet cam tightens when the disc is 47.1 m/m or 15° before top center it is said to open early.

If it does not tighten until the disc is 15.7 m/m or 5° before top center it is said to open late.

Any one of these variations will cause loss of power, perhaps over-heating and countless other troubles.

If the timing is late or early as the case may be, and it is "off" 2° (6.28 m/m) or more on the crankshaft timing, it will be necessary to change the setting of the camshaft in order to get the timing more accurate.

Plate 31

Adjusting the vertical shaft after it has been raised.

Provisions for Adjusting the Camshaft.

Special provisions have been made for correcting the timing in the design of the camshaft drive. The upper vertical shaft is driven from the lower vertical shaft by a screw-driver type of joint, the tongue of which is so located in respect to the teeth of the upper gear that a change of one-half a turn on the vertical shaft gives a change in timing equivalent to one-half a tooth of the camshaft gear. The camshaft itself is driven from its gear by a key placed in one of the five keyways provided in the camshaft. By changing the key one keyway, a change in the timing is made equivalent to 1/5 of a tooth of the camshaft gear.

Plate 32

Adjusting the camshaft and camshaft gear with the vertical shaft gear.

The timing can be corrected by making whichever one of the following changes is necessary, after first setting the line on the timing disc marked "E. C—I.O. 1 and 4 Left" at zero on the scale.

If the timing is "late" advance, and "early" retard the camshaft. See Plates 32 and 33.

a. If the camshaft is 20° or 62.8 m/m "late" or "early" on the timing disc or crankshaft timing, change the mesh of the camshaft gear with the vertical shaft gear one tooth by raising the camshaft, turning the camshaft gear one tooth and replacing the shaft with

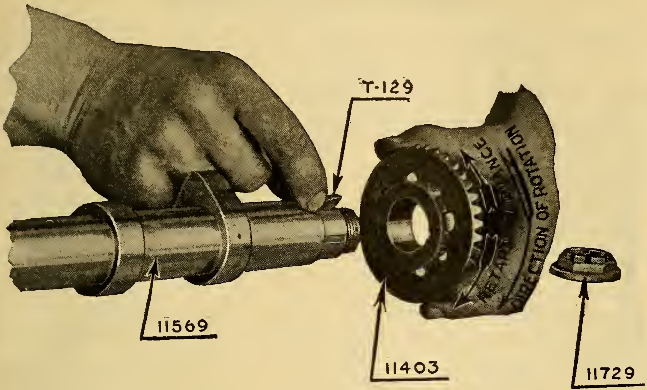


Plate 33

Adjusting the camshaft gear on the camshaft

the inlet and exhaust cams of No. 1-L parallel to their respective tappets, Plate 28. Turn the engine back a quarter of a turn and then slowly in the direction of rotation to check opening as originally done. Plate 26.

b. If the camshaft is 10°-31.4 m/m "late" or "early" on the timing disc or crankshaft timing, remove the camshaft, back off the vertical shaft tube nut No. 11497, raise the vertical shaft by prying gently under its upper bearing with two screw-drivers and turn it one half a turn. Tap the shaft down into position with a block of hard wood, tighten the shaft tube nut and replace the camshaft with the inlet and exhaust cams of No. 1-L parallel to their respective tappets. Turn the engine back a quarter of a turn and then slowly in the direction of rotation to check opening as originally done. Plates 26 and 28.

c. For 4°-12.56 m/m remove the camshaft nut No. 10729, then remove camshaft and drive off the gear No. 11403 by holding the shaft by the first bearing and tapping on the threaded end of the shaft with a fibre hammer. If the opening occurs before the line "I. O, 1

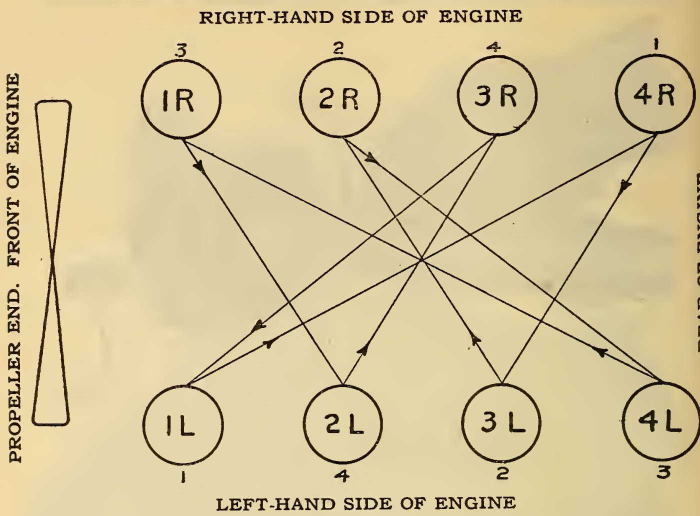


Plate 34
Timing Diagram.

and 4 Left" has reached zero "early," put the key in the next keyway to the left or in the next keyway to the right if the opening occurs after the line has passed zero "late." Replace the gear and put the camshaft in position with the No. 1-L inlet and exhaust cams parallel to their respective tappets. With the shaft in position, tighten and cotter pin the gear nut. Turn the engine clockwise for quarter of a turn and then slowly anti-clockwise to check the opening as originally done. See Plates 33 and 26.

d. For 2°-6.28 m/m remove the camshaft gear nut No. 10729, remove the camshaft and drive-off gear No. 9638. If the opening occurs before the line "I.O, 1 and 4 Left" reaches zero "early," put the key in the second keyway to the left or in the second keyway to the right if the line has passed zero "late." Replace the gear and the nut. Next raise the vertical shaft, turn it one-half a turn and replace as for 10°. Replace the camshaft, with the No. 1-L inlet and exhaust cams parallel to their tappets, then tighten and cotter the gear nut. Turn the engine back for a quarter of a turn and then slowly in the direction of rotation to check the opening as originally done. See Plates 31, 32, 35 and 26.

After setting the left-hand camshaft, place the line marked "E. C. I. O, 1 and 4 Left" directly under zero, being sure that the inlet valve is just commencing to open. Turn the engine in the direction of rotation exactly one-quarter of a turn until "E. C. I. O. 1 and 4 Right" is directly under zero and then proceed to set the right camshaft by following the preceding instructions.

When the correct timing has been secured be sure all the hold-down nuts are tight and cottered as well as the camshaft gear nut. Oil the cams and tappets liberally and replace the valve covers, being careful that the gaskets are in good condition.

The intake opening and exhaust closing on the 4th cylinder, right block, should begin ¼ of a revolution or 90° of the crankshaft after the intake opening and exhaust closing on 1-L cylinder.

The firing order is 1L-4R-3L-2R-4L-1R-2L-3R.

Timing the Camshafts When Cylinders Only are Removed.

The cylinders only having been removed for the purpose of grinding the valves, or the mesh of the lower vertical shaft gears having not been changed with the crankshaft gear, the camshaft can be retimed by proper meshing the camshaft gear with the upper vertical shaft gear. Making sure the screw-driver joint is not a half turn off. In other words it will be unnecessary to change the camshaft gear on the camshaft keyways, unless the engine has been completely disassembled.

Caution: Do not lift the cylinder blocks to reset the vertical shafts.

Table for Advancing and Retarding the Timing of the Camshafts.

To advance the camshaft timing, rotate the gear on the camshaft clockwise, and anti-clockwise for retard, see Plate 33. This is standing at the rear of the engine looking toward the propeller end. The following combinations for timing the Hispano-Suiza camshafts can be obtained. It is given both in degrees and m/m on the crankshaft.

Degrees on Timing Disc on Crankshaft	m/m on 360 m/m Timing Disc on Crankshaft	
2 deg.	6.28 m/m	3 keyways and ½ turn vertical shaft
4 "	12.56 m/m	1 keyway
6 "	18.84 m/m	4 keyways and ½ turn vertical shaft
8 "	25.12 m/m	2 keyways
10 "	31.4 m/m	½ revolution of vertical shaft
12 "	37.68 m/m	3 keyways
14 "	43.96 m/m	1 keyway and ½revolution of vertical shaft
18 "	56.52 m/m	1 tooth less 3 keyway and ½ turn of vertical shaft
20 "	62.8 m/m	1 tooth of camshaft gear
40 "	125.6 m/m	2 teeth of camshaft gear

Revolution of vertical shaft means shifting the vertical shaft in the screw-driver joint.

Keyway means shifting the camshaft gear one (1) keyway on the camshaft.

Tooth means shifting the camshaft gear one (1) tooth on the vertical shaft gear.

Camshaft Regulations.

One revolution of the crankshaft causes ½ revolution of the camshaft, hence 2 degrees on the former equals 1 degree on the latter.

1 degree on 360 m/m disc equals 3.14 m/m on periphery, or .123″ (approximately ⅛″) $\frac{(360 \text{ deg.})}{(36 \text{ T})}=$ 10 degrees on camshaft or 20 degrees on propeller hub or crankshaft.

One tooth on camshaft gear equals 20 degrees or (62.8 m/m) on the crankshaft.

One-half revolution of the vertical shaft divides one tooth in two = 10 degrees or 31.4 m/m on the crankshaft.

One keyway equals $\frac{(36 \text{ Teeth})}{(5 \text{ Keys})}$ = 7 1/5 teeth (drop the seven as instinct and we have) 1/5 tooth = 4 degrees, or 12.56 m/m on crankshaft.

A slight inaccuracy in the spacing of the keyway will make a slight difference for which no rules can be written.

One tooth equals 20 degrees. ½ turn of vertical shaft equals 10 degrees. One keyway equals 4 degrees or 12.56 m/m. From this, the table on page 82 was derived.

PART X

PRECAUTIONS TO BE TAKEN UNDER FREEZING CONDITIONS

Starting an Engine in Cold Weather.

In starting an engine in cold weather never load it immediately after starting. Allow it to operate at partly closed throttle or about 800 r. p. m. In extreme cold weather, we advise stopping it after three or four minutes' operation and waiting a little time until the heat communicates to all parts of the engine.

Precautions to Take When Stopping the Engine.

In order to facilitate starting in the morning and freeing (ungumming) the rings, especially if castor oil is used as a lubricant, we advise giving, while the engine is still hot, after the previous run, several shots of kerosene through the petcocks of the inlet manifolds and turning the propeller over several times.

Anti-Freezing Solutions.

During freezing weather, fill the water circulation system with one of the following anti-freezing solutions:

For a temperature not lower than five degrees above zero:

Alcohol	12 per cent
Glycerine	12 " "
Water	76 " "

For a temperature not lower than five degrees below zero:

Alcohol	15 per cent
Glycerine	15 " "
Water	70 " "

For a temperature not lower than fifteen degrees below zero:

Alcohol	17 per cent
Glycerine	17 " "
Water	66 " "

Alcohol should be added occasionally to make up for evaporation. The glycerine does not evaporate with the water. A simple solution of alcohol, while it is not injurious in any way, lowers the boiling point of the water.

The boiling point of denatured alcohol is about 10 degrees higher than that of wood alcohol.

The use of glycerine raises the boiling point of the solution. It is more expensive than alcohol and is slightly injurious to rubber.

All things considered, a combination solution of alcohol and glycerine in water is the most satisfactory.

Do not use any alkaline or calcium chloride solutions; *they are injurious to the metal parts.*

PART XI

RECOMMENDATIONS FOR ATTACHING PROPELLERS

How to Place the Hub in the Propeller.

In placing a propeller hub in a propeller, always put the keyway of the hub in the axis of the blades, as in Plate 35. Starting the engine by cranking is facilitated if the propeller is keyed in this position for "carrying over compression." Moreover, this recommendation is of vital importance since this position has been adopted for adjustment of the layout for firing the machine gun through the path of the propeller.

Fit of Hub in Propeller.

The hub should be a light press fit in the propeller. Hubs can be pressed in the propeller with an arbour press. If no arbour press is available, we suggest that the hubs be pressed into the propeller by using a large bolt and two blocks with holes drilled in their centre for the bolt. Place the bolt through the centre of the hub and through the centre of the propeller, also through the blocks with a block on each end of the bolt. See that the blocks rest so as to bring the strain directly over the sleeve portion of the hub. Draw down on the block by turning the nut on the bolt. Hubs should not be driven into propellers or removed with a hammer or mallet, as there is danger of splitting the propeller.

Mounting the Propeller on the Crankshaft.

The mounting of the hub on the taper of the crankshaft requires very particular precautions; the hub supplied with each engine has been fitted to its taper by lapping with emery and oil while the key is removed. The hub and crankshaft taper is then thoroughly cleaned and the key replaced, making sure to lubricate the taper and hub with tallow or oil and graphite. This operation should be strictly adhered to each time

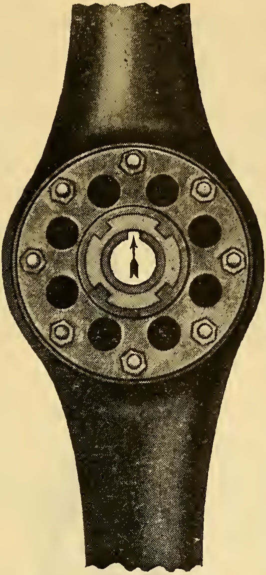


Plate 35

Showing the location of the keyway in the propeller hub in relation to the propeller blades

a new hub or one that shows wear is placed on the crankshaft; always remembering that a bad fit rapidly develops play and if run in this condition will do great damage.

Tightening the Propeller Hub Nuts.

There is one inner propeller hub nut 11913, and one outer propeller hub nut 11914 holding the propeller hub 11887 on the crankshaft, they being locked together with a lock wire 11397.

To fasten the hub 11887 on the crankshaft taper:

1st. Insert the inner nut 11913 in the outer nut 11914, so that both have their hexagon heads at the same end.

2d. The thread on the outside of the outer nut fits the thread on the inside of the hub, screw the nut into

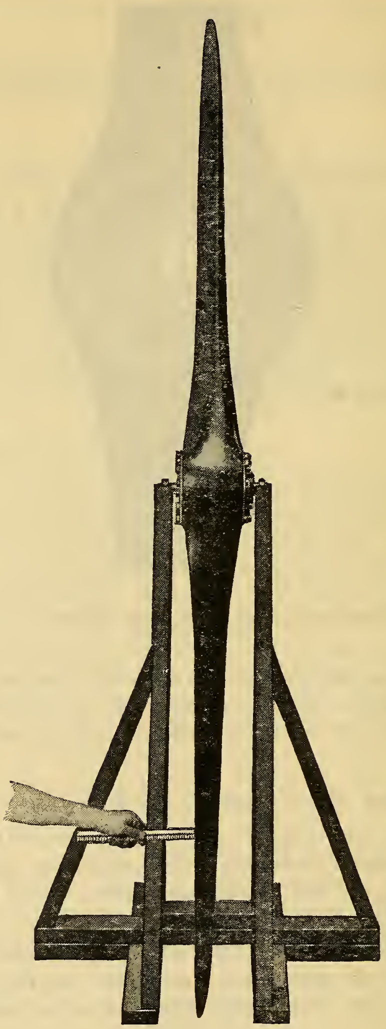


Plate 36
Checking track of propeller.

the hub while the inner nut is still in the outer nut. This can be screwed all the way in until it bottoms and then backed off about three or four threads.

3d. Place the hub on the crankshaft taper and start the inner nut on the thread on the end of the crankshaft by the aid of the wrench 11439, which is found in the tool equipment; pull the nut 11913 "home;" this draws the hub on the crankshaft taper.

4th. After the hub is drawn on the taper, the inner nut is locked in place by drawing up the outer nut, the nuts are then locked together by the lock spring wire 11397, and the operation is completed. See Plates 45 and 46.

Removing the Propeller Hub.

With the aid of wrench 11439 loosen the outer or lock nut 11914 about one or two turns. Then fold the wrench together so that the large hex portion of it will fit on the outer nut, while the small hex portion will fit on the inner nut. Proceed to back off both nuts as one nut, this will remove the propeller hub from the crankshaft, there being a difference in pitch of the threads on the two nuts. This being the amount the hub is pulled off each revolution of the nuts when operated as one nut.

Proper Balance.

A faulty balance or fluttering of the propeller always causes vibration. As soon as this condition is encountered, correct the balance with care and also the pitch (because it happens that wood warps). Plate 36 shows the method of doing this operation.

PART XII

MACHINE-GUN FIRING MECHANISM

The machine-gun firing mechanism or interrupter driving mechanism is driven from either the left or right lower vertical shaft. It is driven by a gear which is pinned to the lower vertical shaft gear.

The interrupter shaft is mounted on two ball bearings and driven at crankshaft speed. Plate 37.

The synchronizing of the interrupter with the pro peller is facilitated by the double flange connection which bolts it to the driving shaft. One flange having one less bolt hole than the other it is possible by removing the two bolts and placing them in different holes to get any desired timing required.

The firing mechanism should be set so that the bullet would just miss the trailing edge of the propeller by about one-half an inch (if gun was loaded) when the engine is turned over by hand.

Test synchronization by cocking the gun and turning the engine over slowly by hand; stop when firing hammer clicks. Sight down the gun to see if the trailing edge of the propeller has passed the end of the gun; this should not pass the gun by less than one-half an inch or more than two inches.

PART XIII

ADJUSTMENTS

Valve Tappet and Cam Clearance.

The clearance between the valve tappets and the cams should be .030″. It is important to check this clearance from time to time and correct it, if it varies, using special wrench No. 12028 and the gauge No. 11141, supplied for the purpose in the tool equipment. See Plate 29.

Water Pump Packing Nut.

By unscrewing set screw B-754 the water-pump packing nut 10770 can be tightened when the water-pump gland nut is found to leak.

Inlet Manifold Packing Nuts.

The inlet manifold and tee packing nuts 11976 or 13433 as well as the oil tubes at the front of the cylin-

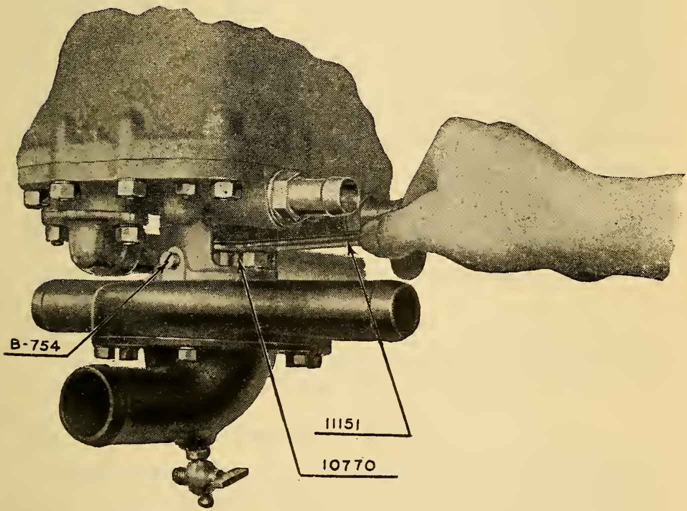


Plate 38

Adjusting water-pump packing nut.

ders at packing nuts A-T-990-A can be tightened when found to leak.

Magneto Breaker.

The magneto breaker should be looked at from time to time to see if it is breaking the proper distance, which is .020″. This can be re-adjusted by the special wrench furnished with the magneto spare parts.

PART XIV

OPERATION

Starting the Engine when Cold.

In starting the engine cold, it is best to prime the engine through the petcocks on the intake manifolds. If the engine is warm no priming should be used.

Setting of the Throttle and Altitude Controls for Starting.

The engine is controlled by gas throttle and is found to start best with a very small opening. The throttle lever should be about 5 m/m or $\frac{3}{16}''$ from the stop screw. The throttle lever is connected to an operating lever in the pilot's cockpit. The second control lever on the carburetor is designed to correct the variations in carburetion required at the different altitudes where the engine is to operate and is also connected to an operating lever in the pilot's cockpit. For starting, and until the engine is warmed up, the altitude-control lever should be in the rich or all the way forward position. After the engine is warmed up, the control can be moved toward the lean position until the maximum r. p. m. of the engine is obtained. This adjustment will generally be found satisfactory up to 1000 meters (3280 feet). Above that, it is necessary to make corrections, always, of course, determined by the revolution counter. As the altitude is increased it will be found necessary to move the lever back or in the lean position.

Location of Starting Magneto.

The starting magneto, when there is one used, is conveniently located in the pilot's cockpit.

Air Pressure in Gasoline Tank.

Before trying to start the engine, make sure there is pressure in the gasoline tank, if a pressure system is used. This being done, place the throttle and altitude-control levers in the starting positions and prime the intake manifold as mentioned above, then, with the ignition switch in the "off" position, turn the engine over two or three times with the propeller, put the ignition switch "on" and turn the starting magneto, the engine should start. If it does not start, repeat the operation.

Kind of Propeller.

The engine should be fitted with a suitable propeller to give from 1600 to 1650 r. p. m. on the ground or sea level when the engine is wide open or all out.

Difference in Engine Speed.

Each machine should be tested in flight to determine the difference between the speed in the air and on the ground. The difference may vary from 50 to 300 r. p. m. It will also be noticed that during a very steep climb of short duration, or a very short turn or bank the engine will be temporarily over-loaded, causing a slight decrease in the number of r. p. m. but will recover itself as soon as it regains normal flight.

PART XV

INSTRUCTIONS FOR STARTING THE ENGINE

Block the wheels of the plane securely.

Setting the Throttle.

For starting the engine the throttle lever should never be opened more than 5 m/m or $\frac{3}{16}''$ from the stop screw.

Setting the Altitude Control.

Place the altitude control lever in the back or rich position.

Priming the Engine.

Prime the engine by injecting a small quantity of gasoline (in cold weather use half ether and half gasoline) through the four priming cocks on the intake manifolds.

Cranking the Engine.

As soon as the engine is primed and with the ignition switch still in the "off" position turn the engine over compression on about three cylinders by the propeller. The man turning the engine over stands aside and the pilot turns the ignition switch "on" and then turns the starting magneto by hand. This should start the engine, providing everything is properly adjusted.

If any trouble is encountered with any particular part of the engine, look under the topic in which this part is described in this "Instruction Book."

As Soon as the Engine is Started.

Let the throttle in approximately the starting position and allow the engine to run at idling speed (not over 800 r. p. m.) for a few minutes or until it is thoroughly warmed up.

Things to Observe After Starting the Engine.

Oil Pressure Gauge.

Gasoline Air Pressure Gauge if pressure system is used.

Water circulation by Moto-Meter temperature.

Operation of the Magnetos by trying each separately.

After the Engine is "Warmed Up."

The altitude-control lever should be moved forward or towards the lean position until the maximum r. p. m. of the engine is obtained.

Caution: Do not attempt to crank an engine immediately after it has been stopped. An over-heated spark plug or red-hot piece of carbon might cause pre-ignition and a disastrous back-kick. Always allow it to cool a few minutes.

PART XVI

DISASSEMBLY

To Remove the Engine from the Plane, Proceed in the Following Manner:

Take off the propeller and hub assembly, see instructions, Page 89. Drain the water from the radiator and engine by opening the petcock 11796 in the lower half of the water-pump.

In most cases it is necessary to remove the radiator before lifting the engine.

Be sure that all connecting members are removed, such as: Tachometer shaft, gun-firing attachments; carburetor control rods; gasoline air pump line; oil and water connections; magneto wires, etc. Make sure all of the oil is drained from the sump.

If a gun is mounted over the engine it should be removed before proceeding to remove the engine.

Remove engine bed bolts and lift engine. See that the slings which are used on the engine do not put any strain on the light members of the engine.

Place the engine on a suitable stand. The engine bed should be bolted down with two bolts if the stand is to be tipped, in order to make the cylinder block stand perpendicular.

Remove carburetor and manifold tee as one. Loosen four nuts at the flange on the end of the tee 13428 and back off the union nut 13433 of the detachable flange inlet pipe. It is not necessary to take the nuts off. Shake tee from side to side and lift it out; do not tear gaskets. See Plate 39.

Remove intake manifolds 13429 by unscrewing the eight nuts at the flanges of the manifold.

Remove the breather pipe by turning it to the left. Use a snubbing device made of a stick of wood and a leather strap.

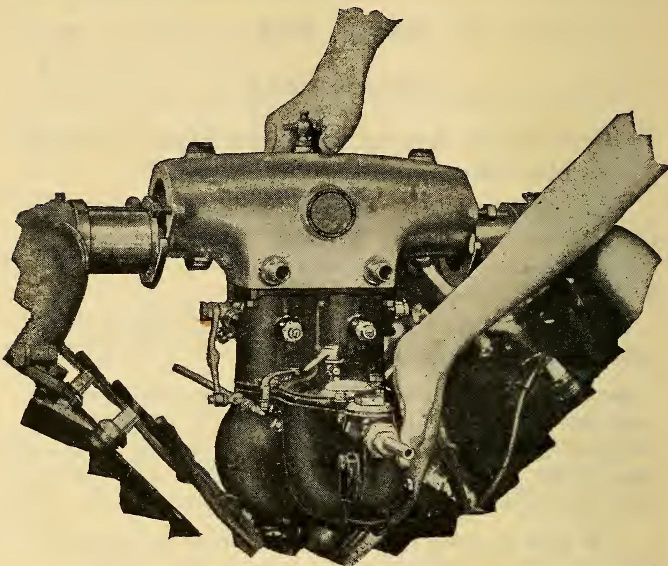


Plate 39

Removing vertical carburetor and tee from engine.

Removing the Magnetos.

Remove the ignition wires and distributor blocks intact. Remove the 8 magneto cap screws 1440. The magnetos, together with their couplings, can be lifted off. Care should be taken in replacing the magnetos, as the magneto on the left-hand side of the engine is a clockwise magneto and the one on the right side of the engine is anti-clockwise, looking from the driving end.

Removing the Camshafts.

When valves are to be inspected or ground, take out the cylinder cover screws 11677 and remove the camshaft covers. Take off the nuts 11302 at the two end bearings of each camshaft first so that the valve springs will not tend to spring the shaft or bearings. Remove the middle bearing nuts next. See that both ends of

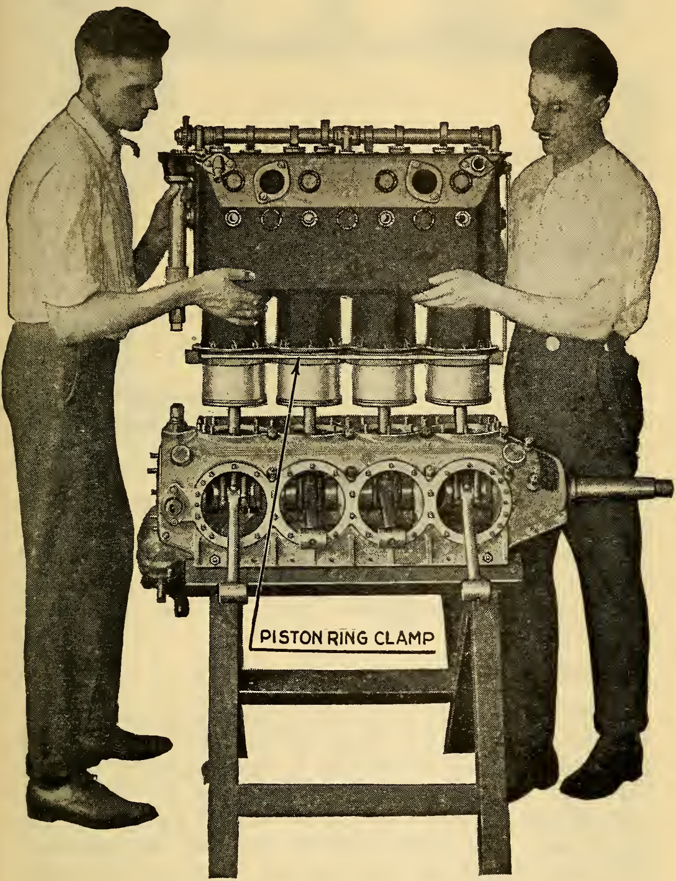


Plate 40
Removing or assembling a cylinder block.

Plate 41

Piston Ring Clamp

the shaft are lifted evenly. If this is done no force will be required. The shaft and three bearings can be lifted together.

Removing the Cylinder Blocks.

Undo the oil pipe nipple packing nuts A-T-990-A at the front end of the cylinder. Undo the gear housing packing nuts A-10357-A at the rear end of the cylinders. Remove the cylinder stud nuts 11305, 76 in number. It is best to let one nut on the upper side of each cylinder block until everything is in readiness to remove one of the cylinder blocks. Turn the crankshaft so that the pistons of cylinder 1 and 4, of, say the left block, are on top. Take off the remaining nut and lift the block away from the upper half of the crankcase and pistons, taking care not to bind the pistons and to support the pistons after they are out of the cylinders. The same operation holds good for the right-hand cylinder block.

Removing the Pistons.

Remove the piston pin guide plugs 11763 on pistons, 1L, 4L, 1R and 4R. Remove the piston pins 11494 this can be done by taking a piece of wood or soft brass and driving them out. See Plate 42. The connecting-rod or piston should be backed up during this operation. The pistons 11731 can then be removed. Turn the crankshaft a quarter revolution and proceed as above with pistons 2L, 3L, 2R and 3R.

Removing the Oil Pumps.

Remove the oil suction pipe assembly by removing the five nuts 11303.

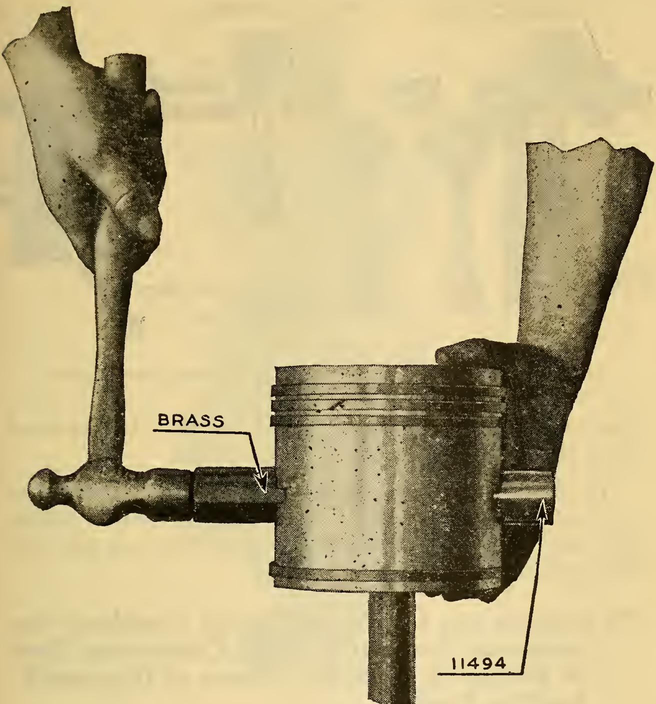


Plate 42

Removing piston from connecting-rod.

The complete oil pump assembly, including the three gear oil pumps, can then be removed from the lower half of the crankcase by removing the 13 nuts B-93 which hold the oil pump cover plate 11916 in place.

The water pump drive shaft No. 11758 can be removed immediately upon taking the oil pump assembly from the crankcase.

To disassemble the oil pressure pump remove the oil pressure pump body 11748. Remove the castled nut 11764 and drive the oil pump drive gear 11752 off the taper end of the oil pressure pump gear 11755.

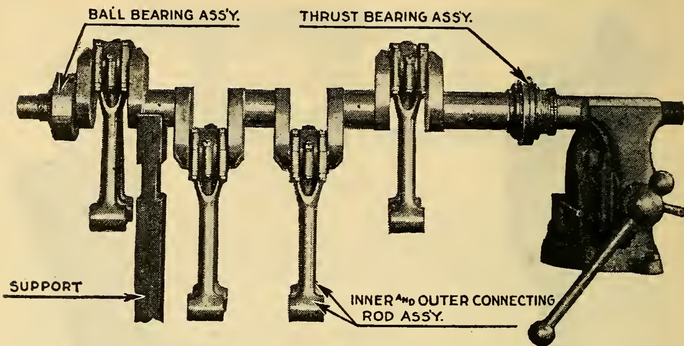


Plate 43

Crankshaft can be supported in this manner for assembling connecting rods.

The oil pressure pump gear 11755 can then be removed from the oil pressure pump body 11748.

To disassemble the oil suction pumps remove the oil suction pump body 11747. The oil suction pump gear 11754 can be removed the same way as was the oil pressure pump gear.

To Remove the Lower Half of the Crankcase for Summary Inspection of the Connecting Rods or Removing it in the Course of Disassembling the Engine.

If the engine cannot be hung in a stand while removing the lower half of the crankcase, the carburetor, together with manifold tee 13428 and both intake pipes 13429 should be removed. Drain all the oil from the crankcase. The engine can then be turned upside down and allowed to rest on the cylinder covers. To remove the above parts, remove 12 nuts 11303, the hose connections to the manifolds having already been removed when the engine was removed from the plane. Then, by removing the 5 nuts 1443, take off the magneto support bracket 13116 at the rear end of the crankcase. Remove the 10 crankcase bearing stud nuts B-933 found on top of the crankcase, also 2 nuts B-933 found at the rear of the bottom half of the crankcase. Then

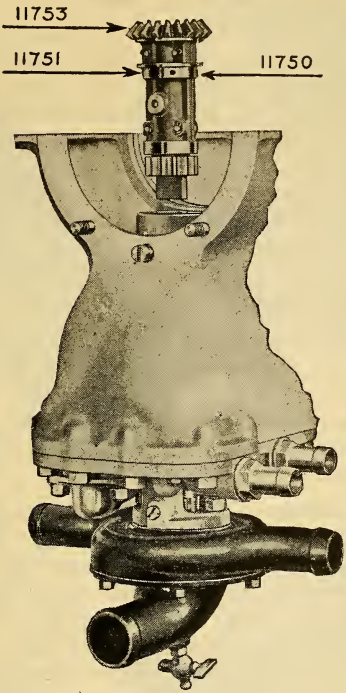


Plate 44

Oil pump gear bearing and gear pump drive pinion assembly being removed from the lower crankcase.

remove 24 nuts 11303 on the outer edge of the case that hold the two cases together. The lower half can then be removed by prying the two halves apart with a screwdriver. Special lugs are cast on the cases for this purpose. If you want to rotate the crankshaft while the engine is in this position, remove the spark plugs on the exhaust side and hold the rear end of the crankshaft in place with a wooden flange drilled with two holes corresponding to the two studs B-938 of the bearing, these being held in place by nuts on the studs.

Removing the Connecting Rods.

Extract the cotter pins from the connecting rod outer bolts 11507 and remove connecting rod outer bolt nuts 11508. The outer connecting rods 11666 can then be removed. Extract the cotter pins from the connecting rod inner bolts 11506 and remove the connecting rod inner bolt nuts 11503. The inner connecting rods 11667, together with the bronze connecting rod bearings 11488 and bronze connecting rod bearing caps 11489 can then be removed.

Removing the Valves.

Put into the cylinders four pieces of wood somewhat longer than the inside of the cylinders and held together by a cross piece attached to the cylinders. Anchor the valve tool on the rod held in place by the studs 948-T of the camshaft bearings and take off each valve, with a special lifter, in the following manner.

Place the hollow yoke of the lever on the top of the valve tappet washer 11970 or 11544. Unscrew the valve tappet with the other hand until the springs are no longer compressed. Dispense with the lifter and finish unscrewing the valve tappets. Remove the washers and springs 11406 and 11407. When this operation is finished for the eight valves, remove the pieces of wood and take out the valves 11969 and 13292.

Dismounting the Water Pump.

The hose connections having been removed when the engine was removed from the plane, unscrew the two nuts 11303 and lower the complete water pump.

Removing the Oil Strainer. See Plate 21.

The oil filter assembly or strainer should be removed. every ten hours of engine running and if found to contain any foreign matter should be cleaned and replaced This can be done by removing the 10 nuts 11303 and the o'l filter chamber cover 11749.

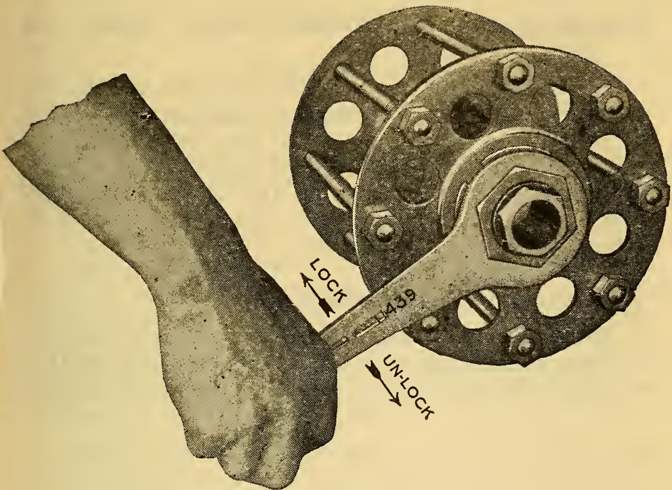


Plate 45

Loosening or tightening propeller hub lock nut.

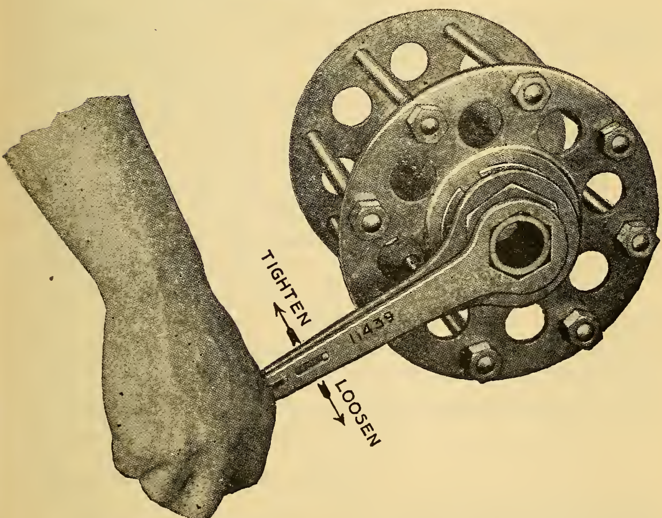


Plate 46

Loosening or tightening propeller hub.

Removing the Oil Pressure Relief Valve. See Plates 17 and 18.

The oil pressure relief valve is located on the left side of the lower half of the crankcase opposite the oil filter. The complete assembly can be removed by unscrewing the oil pressure relief body 11893, and can be taken apart by removing the oil pressure relief plug 11531. The oil pressure relief valve should be cleaned often and thoroughly.

To Remove the Crankshaft.

Always lift both ends of the shaft at the same time. It may be necessary to strike the crankcase with a wooden or rawhide mallet, to loosen the thrust bearing.

PART XVII

MAINTENANCE

After Five Hours' Running.

The distributor of the Dixie Magnetos should be cleaned to avoid any skipping or missing in their operation.

The brushes of the high tension distributors should be oiled, preferably with Three-In-One oil, likewise the path of the brushes in the distributor block should have a light coating of oil. This prevents the scattering of carbon dust in the distributor blocks, which causes short-circuiting or firing in the wrong cylinder.

After Ten Hours' Running.

Before each important flight, clean the spark plugs (with alcohol and gasoline) and adjust the gap to .021″. The magneto distributors, oil filter and oil pressure relief valve should also be cleaned.

Tighten the water gland nut 10770; to do this loosen set screw B-754. This packing nut has a right-hand thread. Plate 38.

The exhaust pipes should be removed from the engine and by means of the propeller, the engine should be turned over compression on each cylinder, feeling the compression to ascertain whether there is any leakage. If an exhaust valve is leaking the escaping gas can be heard coming out of the exhaust port of the particular cylinder. If it is in the piston rings it can be heard leaking from the crankcase breather.

If the valves are found to leak badly they should be reground; if piston rings, they should be renewed. Instructions for this will be found under Disassembly.

Remove the carburetor strainer and clean the strainer chamber as well as the strainer.

After Every Twenty Hours.

Clean the water filter. The water in the water jackets and radiator should be drained and the water jackets

Plate 47

Trying the piston rings for side clearance with a feeler.

and radiator washed out and refilled with clean water. Oil the magnetos.

Every Fifty Hours.

Clean carbon deposits, if any, out of the combustion chamber after the cylinder blocks have been taken off. Regrind the valves (instructions for this will be found under Disassembly and Reassembly). Do not unscrew the steel cylinder sleeves from the water jackets as this is a factory operation.

The interior of the camshafts should be washed thoroughly with gasoline or kerosene and cleaned by turning a jet of compressed air into them. This will remove all sediment of old oil and any foreign matter that may have collected. The same thing should be done with the crankshaft by removing the plugs 11323 and the oil pipes in the lower half of the crankcase by removing the main bearings. This should always be done in case a bearing is burned out, in order to remove any babitt in the crankshaft oil holes or interior of the camshaft.

The main crankshaft bearings should be examined and if found faulty should be renewed. Examine the connecting rod bearings 11488 and connecting rod bearing caps 11489, if found faulty they should be replaced. If these are replaced, the flat surface on the top of 11488 should be scraped to fit the flat ends on the lower end of the connecting rods 11667.

All piston rings and oil scraper rings should be renewed. See Plate 47.

All rubber hose connections should be examined and if found extra soft or leaking should be renewed. There is extra hose supplied in the spare parts box shipped with each engine.

The oil pump gear bearing 11750 and 11751; vertical shaft bearings (lower) 11634; vertical shaft bearings (upper) 11402; camshaft bearings A-9619-B, 11373, and 11374 and 11375, should be examined. Some times there happens to be an excess amount of dirt or foreign substance in the oil, causing the bearings to wear much faster than they should. Under ordinary conditions these should not need replacing after 50 hours of running.

The valve tappets 11972 should be examined for excessive wear and renewed if found necessary.

The valve guides and valves should be examined; if excessive wear is found in the guides, or the valves (particularly the exhaust) burnt they should be renewed.

Caution About the Renewing of Valves.

Never renew a valve that needs only regrinding. Always remember that an old valve reground is always

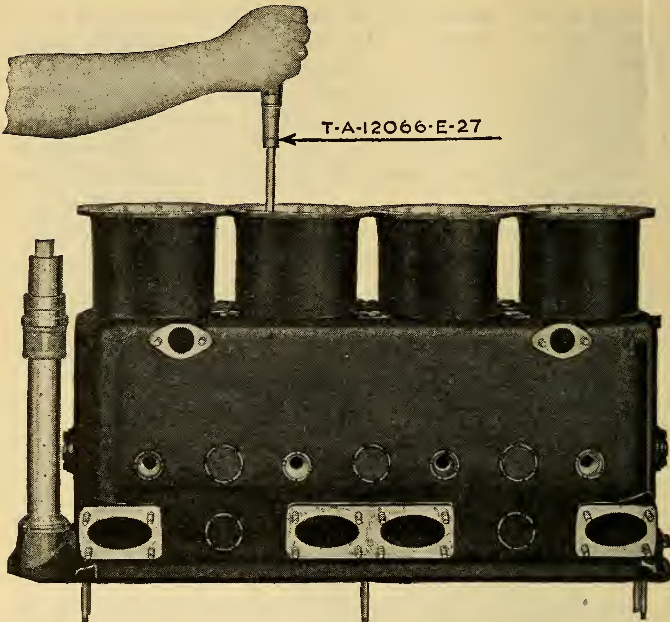


Plate 48
Grinding Valves.

better than a newly fitted valve. The reason for this being that the old valve has had all the strains removed in the steel due to the heat under which it is subjected while being pounded on its seat. An old valve when properly reground will hold its seat and will not warp nearly as soon as a new one.

Fitting New Connecting Rods to the Crankshaft.

The inner connecting rod bearing cap should be first fitted to the crankshaft. Do not, under any circumstance, remove any metal from the connecting rod bearing 11488 and bearing cap 11489 where they are joined together as this will spoil the fit of the outside connecting rod which runs directly on the center of the bronze.

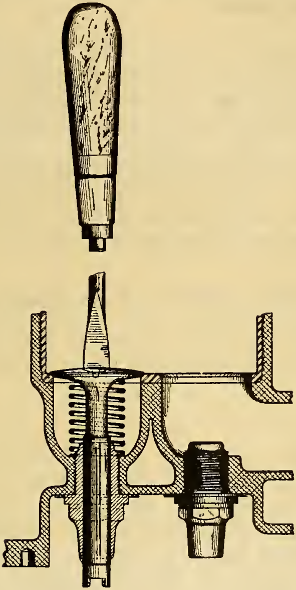


Plate 49

Showing relief spring placed under the valve when grinding the valve.

The babbitt of the inside diameter of the bearing 11488 and cap 11489 are machined smaller than the crankshaft, leaving metal to ream out to the crankshaft diameter, or spotted with blue and scraped until the bearing is .002″ loose on the crankshaft diameter. The end clearance between the inner connecting rod and crankshaft should be .009″.

After the inner connecting rod is fitted to the crankshaft and locked in place the outer rod can be placed over it and should be fitted .004″ loose on the diameter and .007″ end clearance on the inner rod.

Fitting a New Ball Bearing on the Rear End of the Crankshaft.

The inner race of the ball bearing should be a loose fit on the crankshaft and is locked in place by the crankshaft gear 9638. The crankshaft gear is held in place by the crankshaft centering lock nut 10637.

The outer race of the ball bearing should be a .0005″ loose fit in the upper and lower crankcases. This is to allow the race to creep in the crankcases and thus distribute the wear in the ball bearing.

Fitting New Camshafts or New Camshaft Bearings

The camshafts have three bronze bearings, the center one is made in two pieces in order to get the bearing on the shaft.

The thrust (in both directions) is taken care of by the rear bearing. The boss on the back of the camshaft gear comes in contact with one end of the rear bearing while the rear face of the exhaust cam No. 4 cylinder runs against the outer end of the bearing. The end play between this bearing and shaft should be .020″. The end play between No. 1 exhaust cam and the front bearing should be .025″. All six bearings are fitted with .003″ clearance on the diameter.

There should be a back-lash of .010″ between the upper vertical shaft gear and the camshaft gear. The back faces (or end of the teeth) should be flush within (one thirty-second of an inch) $\frac{1}{32}$″.

Grinding the Valves.

It is necessary to remove the cylinders from the engine and also remove the valves from the cylinders, they can then be reground in the following manner: In Plate 48 it will be noticed the cylinder block is inverted and a long bladed screw-driver is being used to grind in the valves.

A light spring is inserted under the valve to partially counterbalance the weight of the tool used for turning the valve. See Plate 49. Abrasive should be applied to the valve seat and the valve placed in the particular cylinder in which it belongs.

In grinding the valve, do not revolve it, but rock it backward and forward, lift frequently off its seat, change its position on the seat in order to distribute the abrasive evenly and prevent cutting grooves in the valves, and also to grind the valve evenly.

Valves should not be reground any oftener than is absolutely necessary and then only enough to insure a perfect seat. If a valve is pitted or warped excessively, it should be placed in a grinding machine and its seat ground concentric with the stem, removing all pit marks and any warping. In the case of valve warping the valve seat in the cylinder should be trued with a valve seating reamer before grinding in the valve.

The abrasive should be carefully washed off the valve, the seat and the inside of the cylinder.

In emergencies the cylinder block can be layed on its side on a bench and the valves removed without either wooden blocks, cradle, or yoked tool, but it takes longer, and the tools are well worth having, as they save time and give better results.

Testing Valves for Leaking.

After being ground the valves should be tested for tightness. This can be done best by inverting the cylinder with the valves in place and pouring a small quantity of gasoline in the cylinder. Spark plugs will have to be screwed in the cylinders to keep the gasoline from running out. Watch for escapage around the valves. If the valves show any leak, they should be carefully reground.

Regrinding the Seat on the Valve in a Grinding Machine.

The grinding of valve seats in a grinding machine previous to grinding them by hand in the cylinder is

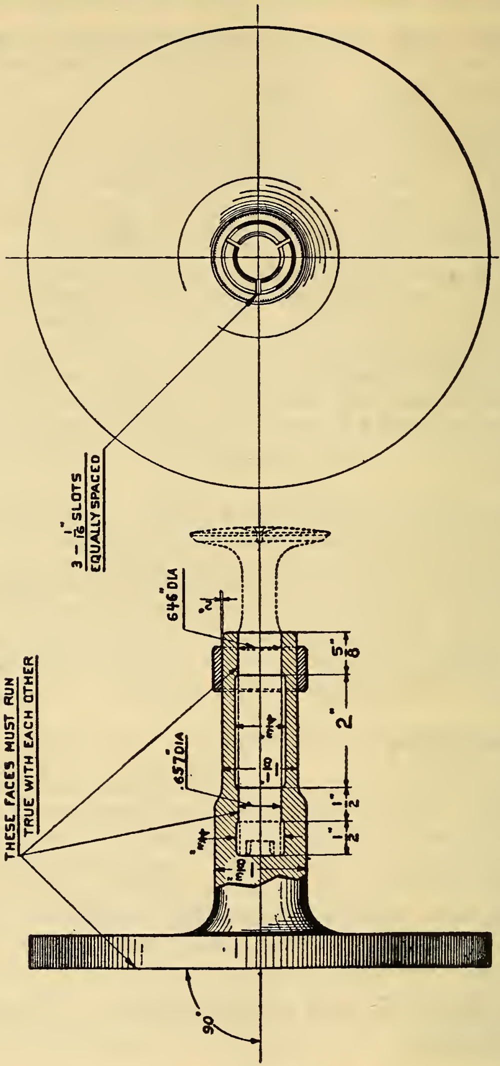


Plate 50

One form of fixture that can be used for holding valves while grinding the seats in a grinding machine.

resorted to only when the valve seat is badly burned or pitted.

The valve can be chucked in a fixture similar to that shown in Plate 50 and the fixture placed in a small grinding machine.

The valve seat can then be ground true with the stem by using some form of grinding wheel.

Caution: Under no circumstances use the center in the valve head for regrinding, when regrinding in a grinding machine.

The valve is now ready to be reground in its particular seat in the cylinder as explained above.

Refacing the Valve Seat in the Cylinder.

If the valve seat in the cylinder is burned or pitted so that it would require a great amount of grinding to make a proper seat, it can be reseated with a special tool, as stated above. This tool can be furnished by the Wright-Martin Aircraft Corporation.

The shank that fits in the valve guide must be a perfect fit otherwise the reamer will chatter and do more harm than good. There are two shanks furnished, one for inlet valves and one for exhaust valves. Do not take any more metal off than is absolutely necessary to "true up the valve seat," otherwise the seat will become too wide.

Fitting a New Crankshaft and New Crankshaft Bearings.

In fitting a new crankshaft if the main bearings are badly worn or cracked, it is best to replace them with new bearings.

The same will apply to the connecting-rod bearings.

Assuming the engine has already been taken apart, as the discussion of this is taken care of under "Disassembly," and that new bearings are to be fitted, proceed as follows:

The upper halves of the main bearings should be fitted in the upper half of the crankcase. They should be driven into the crankcase by light tapping, using a block of hard wood, against the bearing. The case should be blued where the bearings fit and the bearing removed to see if it has a good bearing contact in the crankcase, if not, the case should be scraped to fit. The same should be done for the lower half of the crankcase.

The crankcases with their main bearings fitted should be bolted together and if a line reamer is available they should be line reamed.

The crankcases being separated, the crankshaft can be tried in each half, taking note of the end clearance on the bearings, about .085" the thrust of the crankshaft being taken, in both directions by the ball. thrust bearing. The crankshaft should have a light coating of blue placed on it and the bearings marked from the shaft, they should be well spotted from the shaft and if not should be hand scraped until all the high spots are removed. After all hand scraping is finished and a good bearing is obtained, the bearing should be burnished with a smooth dull edged tool. The crankcases should be bolted together with the crankshaft in place. It should be possible to rotate the crankshaft when in place, with very little effort. The crankshaft should be removed from the crankcase to assemble the connecting rods. As in Plate 43.

PART XVIII

REASSEMBLING

Caution.

Care should be taken to cover all frictional surfaces freely with a good grade of gas engine cylinder oil when reassembling an engine and to see that all parts are thoroughly cleaned both inside and outside.

The inner connecting rods with their bronze connecting rod bearings are used on the left-hand block of cylinders, the outside rods operating on the right-hand block. Without any compression it should be possible o turn the engine over by hand on reassembly, by means of the propeller hub flange.

Oil Pumps in the Lower Crankcase.

The three oil pumps are bolted to an aluminum cover plate 11916 which is bolted to the lower half of the crankcase just above the water pump. The oil pump cover plate 11916 has inlet and outlet passages cored in it, the oil pump hose connections 11776 being screwed into these passages.

The oil suction pump body 11747 and the oil pressure pump body 11748 are bolted to the oil pump cover plate and must be a good fit as there is no gasket used under them.

The oil pressure pump gear 11755, oil suction pump gears 11754, oil suction pump idler gears 11756 and oil pressure pump idler gear 11757, should have about .003″ end play when the pump bodies and cover plate are bolted together.

When the oil pump assembly is bolted to the lower crankcase make sure to place gasket 11916 between them.

After the oil pump assembly and gear pump drive pinion 11753 are assembled in the lower crankcase, try the back-lash between the oil pump drive gears 11752 and the gear pump drive pinion 11753, it should be about .012″.

Water Pump.

The water pump has only one moving part, *i e.*, the shaft and impeller are integral. The thrust bearing is a thrust button placed directly under the center of the shaft. When the pump is assembled with a paper gasket between the body and the cover the shaft must have an end play of about .010″. The impeller should spin easily when the pump shaft is twisted by the fingers. When the packing nut is repacked and screwed down, one should be able to turn the impeller with their fingers. Place the pump on its bracket so that the petcock will point towards the rear of the engine. The square head of the impeller shaft fits in the water-pump drive shaft. When all oil pumps and water pump are in place one should be able to turn all the pumps by hand with the oi pump gear 11753.

Lower Crankcase.

After assembling the oil pumps and water pump to the crankcase, replace the oil filter assembly and, if found necessary, put a new gasket 11918 under its seat on the crankcase. Inspect bearings to see that they have been burnished properly and that they fit the crankcase. They should be tight in place and a uniform fit. A .0015″ feeler must not enter between bearing and case at any of the margins. Cover the crankcase with a cloth to keep out dirt, if allowed to stand while the remainder of the engine parts are being assembled.

Assembling Connecting-Rods to Crankshaft.

Replace crankshaft plugs if they were removed. To lock these plugs, use a center punch and hammer. Never remove any metal from any part of the crankshaft for any reason. The crankshaft has been dynamically ballanced with great care and it must not be put out of balance. The front of the shaft is the tapered end. The inner connecting-rods with bronze boxes go on the left side of the engine and the outer rods go on the right side of the engine. The top half of the crankcase inverted can be used to hold the crankshaft while the connecting-rods are being assembled, but it is preferable to do it at the bench. The crankshaft ends can be held in wooden collars. See Plate 43. Tighten and lock the four inner connecting-rods in place. Be careful about the plugs in the crankshaft throws between the crank arms; they may bruise the babbitt on the rods. Be sure the caps and cap screws are in their correct places. See that the cotter pins are placed so they will not interfere with the crank arms. Do not use a small pin, use the largest cotter pin that will enter the hole. The connecting-rods must have at least nine-thousandths of an inch (.009″) end play on their journals. Try the rod to see if it will fall of its own weight; it should. Try to detect any binding by moving rod all the way around. The fit must be easy and uniform, that is, when turning slowly by hand, there shall be no noticeable change in friction. Be sure to get the proper rod in the proper place; all are marked. Also have the front side of the rods to the front. The side with the number on the rod portion goes to the front of the engine in both cases. The four outer rods go on next—see that their cotter pins do not interfere with the inner connecting-rods. When both rods are assembled, take one in each hand and try for uniform fit—see that there is no variation in the friction. When released, both rods should fall of their own weight. Binding is due to one or more of four things—too tight (generally)—interference at ends—rough places or rods sprung. Great care must be taken when remedying these ailments. The bearings when new are necessarily free and after being worn cannot be taken up for wear but have to be renewed. See "Fitting New Connecting-rods to the Crankshaft."—Part XVII.

Assembling Thrust Bearing to Crankshaft and Crankcases.

The thrust bearing consists of three races and two sets of balls. The balls are assembled in retainers. On the middle race there is pressed two cup rings. The outside of these rings are ground so that the midde race with the rings assembled will just fit their seat in the crankcase. This fit must be a close uniform fit. The race should go into its seat in both the upper and lower half of the crankcase when struck with the hand. It is sometimes necessary to scrape a few burrs and high spots from the sides of the grooves in the crankcase. After fitting the race to the crankcase fit the complete thrust bearing to the crankshaft. The propeller thrust bearing nut 13320 holds the thrust bearing in its place. This nut also adjusts the play. It should be tight enough so there is no perceptible play, yet the middle race must spin when slapped with the palm of the hand. The thrust bearing locates the crankshaft laterally, so try the shaft in place before locking the nut. There should be about .085″ clearance between the faces of the crank arms and the ends of the main bearings. If the shaft lays too far one way remove the thrust bearing and turn it around so the race which was in front comes in the rear and see if it is better. Also try turning the middle race around. When the shaft is set satisfactorily lock the gland nut 13320. If a new thrust bearing has been installed it will be necessary to drill a new hole for the locking wire. Use a No. 39 drill. Drill a hole ¼″ deep in the shaft. After locking the nut make a punch mark on the shaft at the edge of the threads to indicate the location of the hole just drilled.

Placing the Crankshaft Assembly in the Crankcase.

The crankshaft is now ready to be placed in the lower half of the crankcase. It must be lowered into place level so the thrust bearing will not bind. One man holding connecting-rods 4L and 4R to hold up the rear end of the shaft. Another man at the front of the shaft can hold the tapered end in one hand and tap the top edge of the thrust bearing with the other hand. As the thrust bearing goes into place, the rear end of the crankshaft should be lowered.

Joining Crankcases.

See that the meeting surfaces are clean on both upper and lower halves. Shellac both and proceed to join the halves together. Tighten the two main bearing nuts at both ends first, so that the parting line will be pulled together before the shellac sets. Try the two lower vertical shaft gears 11640 and the oil pump gear A-10499-B to see that they have six to ten thousandths of an inch (.006″-.010″) end play and four to seven thousandths of an inch (.004″-.007″) backlash. If the gears bind or have too much backlash see that the crankshaft is in place and well seated. See that the gear bushings are in place. See if the gear on the crankshaft is tight. The lateral position of the crankshaft is determined by the thrust bearing, therefore, the position of the crankshaft gear is fixed by the thrust bearing. Check everything thoroughly. When tightening the main bearing nuts, watch for studs which are too long. They can be detected when screwing the nuts in place. If the nut tends to spring back slightly when released, it shows that the nut is tight on the end of the stud and has not reached the crankcase; further tightening may twist the stud off —in any event damage a few threads. When a long stud is found remove the nut, and with a stud driver screw the stud into the crankcase far enough to allow the nut to seat properly. All of the nuts should be drawn down flush and then gone over and drawn tight, being careful not to draw them too tight. In some cases studs have been elongated by too much tightening. One whole revolution after they bear on the crankcase is sufficient and if some seem to be sufficiently tight before one turn is secured, stop. To lock these nuts, wire the heads of the opposite nuts together. Each of the nuts along the parting line of the crankcase must have a lock washer.

Fitting Piston Pin.

The piston pin must be a tight fit in the piston. (An easy drive fit.) The pin must be a free fit in the head of the connecting-rod. The inside diameter of the connecting-rod bushing is reamed to 1.380″±.0005″ and the outside diameter of the pin is 1.378″±.001″ diameter. This allows about .002″ to .003″ freedom and should never be less. The end play of the connecting-rod at the piston pin should be about $\frac{3}{32}$″.

Fitting the Pistons on the Connecting-Rods.

The pistons should be placed over the upper end of the connecting-rods and the piston pins 11494 driven in place with a piece of wood or brass. (See Plate 42.) The piston pin guide plugs 11763 should then be inserted in the pistons.

Assembling Valves in the Cylinders.

In assembling the valves great care should be taken not to use an inlet valve for an exhaust valve. This also holds good for installing new valves. The stem clearance being larger on the exhaust valves than the nlet. The method of assembling the valves is the reverse of "Removing the Valves" which is found under "Disassembly." Part XVI.

Assembling Vertical Shaft and Vertical Shaft Casing in Cylinders.

Place vertical shaft thrust washer 11730, with the taper side towards the gear, on the vertical shaft gear upper 11728, then place the vertical shaftbearing upper 11402 on the vertical shaft and the vertical shaft-gear collar 11729 placing them on the upper gear end of the shaft and pinning the collar, making sure there is ten-thousandths of an inch (.010″) end play between the bearing and shaft. The shaft together with the bearing can then be placed in the cylinder and by light taps driven into place. Place the vertical shaft casing (upper) 11725 over the vertical shaft and with the Spanner wrench furnished with the tool equipment screw the casing on to the portion of the bearing which protrudes through the cylinder, the casing nut going against a shoulder of the cylinder and is locked by a spring lock ring.

Assembling the Cylinder Blocks.

The valves should be in their places before the cylinders are placed, as they cannot be placed afterward. If the oil pipe is assembled to the cylinder see that the packing nut T-990 is slipped upwards on the pipe. It can be held there by a little packing. Turn the crankshaft so that the heads of the four pistons on one side are level with each other. If an assembly stand is used that, when tipped over, brings the pistons of this block vertical, this should be tipped. Then attach the vertical shaft casing lower 11639. Turn the piston rings so that the joints are 120° apart (The slots should be alternately left and right.) Hold the piston rings in place by means of an aluminum ring clamp or jig. (See Plate 41.) One man at each end of the cylinder block can lower it on the pistons and a man at the side can remove the clamp. (See Plate 40.) The cylinder block will go down of its own weight. Remove the ring clamp when the upper rings are recessed in the cylinders; replace the clamp to confine the oil rings at the bottom of the pistons. When all rings are in the cylinders, remove and dispose of the clamp. If the vertical shaft is assembled turn it so the tongue will enter the groove in the lower vertical shaft. See that the oil pipe enters the union fitting. Tighten the cylinder, stud nuts 11305, the oil pipe packing nut and the vertical shaft packing nut. Tip the stand 90° (if one of this kind is used) in the opposite direction until the other side of the engine is vertical, turn the crankshaft a quarter of a turn, always in the direction of rotation, and go through the same procedure for the other block of cylinders.

Timing the Camshafts.

Valve tappets or mushrooms and cams should be smooth, remove score marks with a stone. If scoring is very deep, new tappets are required. When screwed down tight, the mushroom must be within .002″ of being square with the valve stem. To test, set the valve stem in "V" blocks and use an indicator.

Timing will be found under a separate topic "Valve Timing." Part IX.

Timing the Magnetos.

This will be found under a separate topic "Ignition System." Part V.

The Tachometer Drive Shaft Attachment.

The tachometer drive shaft when assembled shall have $\frac{1}{32}''$ end play. The end play should be tried at several different places during a revolution. The shaft might bind at one place and not at another. The binding is due to misalignment, provided the swivel is perfectly free before being assembled to the engine. Sometimes placing the swivel a half turn from the original setting rectifies the trouble. If not, place a heavier washer under the tachometer housing where it screws into the cylinder cover.

Emergency Assembly.

In cases where piston ring clamps or engine stand is not available, the engine can be assembled by inserting the pistons (with their connecting-rods) in the cylinders by holding the rings of the pistons with a piece of sheet metal bent around the pistons (each piston having a separate clamp).

MEMORANDUM

PART XIX

TROUBLE CHARTS

PART AT FAULT	TROUBLE	HOW IT EFFECTS THE ENGINE	REMEDY
SPARK PLUGS	Oil deposit	Missing	Clean the plug; if this does not help replace with a new plug.
	Carbon deposit	Missing	Clean the plug, if this does not help, replace with a new plug.
	Points too close	Missing or skipping	Reset to .021″.
	Points too far apart	Missing or skipping	Reset to .021″.
	Cracked insulator	Missing or skipping	Replace with new plug.
	Leaking by threads in cylinder	Loss of compression	Screw plug tight in cylinder.
	Leaking by insulator	Loss of compression, missing	Replace with new plug.
VALVES	Warped or pitted on seat	Loss of compression. If inlet valves, may blow back in carburetor	True up on grinding machine and grind to seat.
	Burnt on seat	Loss of compression	If not burnt too bad, true up on grinding machine and grind to seat.
	Too tight in guide	Miss and skip (blow back in carburetor if inlet) loss of compression	Free the valve stem with crocas cloth. See Plate for clearance. Regrind valve.

PART AT FAULT	TROUBLE	HOW IT EFFECTS THE ENGINE	REMEDY
VALVES—*Continued*	Too loose in guide	Seat will not stay ground, miss and skip, loss of compression after running a while	Renew valve if worn. If still too much clearance, renew guide. See Plate for clearance.
	Carbon under seat	Missing, loss of compression	True up in grinding machine and regrind.
	Closes late	Engine miss and loss of power	Check clearance on back of cams and valve tappets .030″. Retime camshafts.
	Opens early	Engine miss and loss of power	Check clearance on back of cams and valve tappets .030″. Retime camshafts.
	Closes early	Engine miss and loss of power	Check clearance on back of cams and valve tappets .030″. Retime camshafts.
	Opens late	Engine miss and loss of power	Check clearance on back of cams and valve tappets .030″. Retime camshafts.
MAGNETOS	Dirty distributors (DIXIE)	Missing or skipping	Clean out any carbon deposit and give a thin coating of Three-In-One oil.
	Breaker points not adjusted right	Missing or skipping	Adjust to .020″.
	Broken down condensor	Missing, sparking and burning of platinum points	Replace with new condensor.
	Loose or broken wire in distributor block	Miss on that particular cylinder	Tighten or renew wire, if broken.

PART AT FAULT	TROUBLE	HOW IT EFFECTS THE ENGINE	REMEDY
MAGNETOS—*Continued*	Collector brush or armature broken or dirty (SIMMS)	Missing	Renew, if broken; clean, if dirty.
	Armature shaft broken	ONE magneto will not work, loss in power.	Replace with new magneto.
	Magnetos weak	Missing	Recharge magnets.
	Punctured or burned-out coil	Missing or magneto dead	Replace with a new coil.
CARBURETOR	Lean mixture	Backfire in air inlet of carburetor	Enrich the altitude control adjustment.
	Rich mixture	Engine run uneven	Lean the altitude control adjustment.
	Engine run uneven idling		Screw out to "LEFT" on the idle adjustment. "LEAN."
	Engine backfire idling		Screw in to "RIGHT" on the idle adjustment. "RICH."
PISTONS AND PISTON RINGS	Piston walls scored	Poor compression and loss of power	Replace with new rings. If extra bad replace with new pistons and rings.
	PISTON—RINGS—Scored	Loss of power	Replace with new rings.
	Worn or broken rings	Loss of power	Replace with new rings

PART AT FAULT	TROUBLE	HOW IT EFFECTS THE ENGINE	REMEDY
PISTONS AND PISTON RINGS—*Continued*	Slots in line	Loss of power	Respace on piston.
	Loose in grooves	Oil works by rings into combustion chamber	If new pistons are not fitted, fit with oversize *width* rings.
	Loss of spring	Loss of power, oil working into combustion chamber	Replace with new rings.
TIMING	VALVES: Camshafts not properly timed	Loss of power, backfiring in carburetor	Correct timing of camshafts.
	Clearance between back of cams and valve tappets not enough	Changes the point of opening and closing of valves, loss of power	Set to .030″ clearance.
	MAGNETOS: Too much advance	Loss of power, pre-ignition	Set magneto to fire 25° before dead center on the compression stroke.
	Not enough advance	Loss of power, water in engine and radiator overheating	
OIL PUMP AND LUBRICATION	Insufficient oil	Oil pressure drops	Replenish oil supply.
	Poor oil	Loss of power	Renew with good grade of oil as specified under "Lubrication System."
	Dirt in oil	Burned-out bearings	Take engine down and renew bearings. Clean thoroughly.

PART AT FAULT	TROUBLE	HOW IT EFFECTS THE ENGINE	REMEDY
OIL PUMP AND LUBRICATION–*Cont'd*	Pressure drops at times		Examine oil pumps. Examine the oil to see if it is clean.
	Excessive pressure		Oil relief valve stuck. Remove valve and examine. Oil may be cold.
WATER PUMP AND WATER CIRCULATION SYSTEM	Water does not circulate	Loss of power, due to water in radiator overheating	See if water pump shaft is broken, clean water system. Impeller may be broken. Replace, if found broken.
MAIN BEARINGS	Babbitt burned out	Knocking, loss of power, drop in oil pressure	Replace with new bearings.
CONNECTING ROD BEARINGS	Babbitt burned out	Knocking, loss of power, drop in oil pressure	Replace with new bearings.
	Bolts on connecting rods break	Knocking, loss of power	Replace with new bolts and repair any other damage.
CYLINDERS	Scored wall	Knocking	Replace with new set of cylinders.
	Water leak in jacket	Will not hold water	Repair leak or replace with new cylinder.
	Jacket covered with scale or clogged with dirt	Knock caused by overheating	Dissolve scale and flush out water jacket with water under pressure.
TIMING GEARS OR CAMSHAFT DRIVE	Worn or broken teeth meshed too deeply	Metallic knock, or rattle, grinding	Replace with new gears. Mesh properly.

MEMORANDUM

PART XX

DATA

HISPANO-SUIZA MODEL "H" 300 H. P.

Number of Cylinders........8
Bore of Cylinders........140 m/m=5.511″
Stroke of Cylinders........150 m/m=5.905″
Displacement........18472.7 Cu. Cm.—1126.42 Cu. In.
Weight of Engine, complete with propeller hub, flange and bolts, carburetor mounted, two magnetos, but without radiator, water, oil, starting device, propeller or gasoline supply system, approximately, ...600.00 lbs.
Compression Ratio........5.30 to 1
Brake Hose Power, on Ground........300
Firing Order........1L-4R-3L-2R-4L-1R-2L-3R
Rotation of Engine, standing at back and looking toward propeller........Clockwise
Rotation of Camshafts (looking toward propeller) ....Anti-clockwise
Speed of Camshafts........One half engine speed
Tachometer Connection Rotation (Looking toward propeller)........Anti-clockwise
Tachometer Connection Speed......One half engine speed
Diameter of valves (at clear)........56 m/m—2.205″
Lift of Valves........13 m/m— .511″
Clearance between back of cam and valve tappet.......030″
Rotation of right-hand magneto (Looking at driving end)........Anti-clockwise
Rotation of left-hand magneto (Looking at driving end)........Clockwise
Magneto speed........Same as engine speed
Gap on magneto platinum points........5 m/m—.020″
Spark Plug Point Gap........021″
Maximum Gasoline Consumption per H. P. hour....54 lbs.
Gasoline Consumption, gallons per H. P. hour on ground, about........100 liters —26⅓ gal.
Gasoline Air Pressure (Not Over)........2 lbs.
Maximum Oil Consumption, lbs. per H. P. hour .030
Oil Consumption, per hour on ground, about .... 4¾ liters—5 qts.

Delivery of oil pressure pump against 60 lbs. pressure at 1800 R. P. M. of engine and at 66° C. or 150° F, about.......3 gal. per minute
Lifting capacity of each oil suction pump at 1800 R. P. M. of engine and at 66° C. or 150° F.—about.......3 gals. per minute
Oil pressure with oil temperature at 66° C. or 150° F. about.......60 lbs
R. P. M. of oil pumps.......Engine Speed
Amount of oil in lower crankcase.......Dry Sump.
Rotation of oil pressure pump driving-gear looking from top.......Clockwise
Rotation of oil suction pump driving-gear looking from top.......Clockwise
Oil temperature, even in the hottest weather, not to exceed.......93° C. or 200° F.
Desired oil temperature.......71° C. or 160° F.
Delivery of water pump with free outlet at 43° C. or 110° F. and 1800 R. P. M. of engine about.......35 gal.
R. P. M. of water pump.......1.2 times engine R. P. M.
Rotation of water pump looking from top.......Anti-clockwise
Maximum outlet water temperature.......88° C. or 190° F.
Desired outlet water temperature.......43° C. or 110° F.
Intake opens.......10° Early
Intake closes.......62° Late
Exhaust opens.......62½° Early
Exhaust closes.......29½° Late
Spark Advance on 360 m/m dia. disc.—78.5 m/m or 25° before top center.
Degrees inlet valves remain open.......252°
Degrees exhaust valves remain open.......272°
Carburetor: Vertical Twin Type (Stromberg NA-D6)
Barrel diameter.......2.375″
Choke diameter at throat.......1-13/16″
Accelerating metering nozzle No. 32 Drill
Carburetor: "V" Type (Stromberg NA-V6)
Barrel diameter.......2.375″
Choke diameter at throat.......1-11/16″
Accelerating metering nozzle.......

PART XXI

REFERENCE TABLES

METRIC CONVERSION TABLES

METRIC TO ENGLISH

Metric Units	M/M to Inches	Meters to Feet	Kilometers to Miles	Liters to Gallons	Kilograms to Pounds
1	0.03937	3.28083	0.62137	0.26418	2.2046
2	.07874	6.56167	1.24274	0.52836	4.4092
3	.11811	9.84250	1.86411	0.79253	6 6139
4	.15748	13.12333	2.48548	1.05671	8.8185
5	.19685	16.40417	3.10685	1.32089	11.0231
6	.23622	19.68500	3.72822	1.58507	13.2277
7	.27559	22.96583	4.34959	1.84924	15.4324
8	.31496	26.24667	4.97096	2.11342	17.6370
9	.35433	29.52750	5.59233	2.37760	19.8416
10	.39370	32.80833	6.21370	2.64178	22.0462
11	.43307	36.08917	6.83507	2.90595	24.2508
12	.47244	39.37000	7.45644	3.17013	26.4555
13	.51181	42.65083	8.07781	3.43431	28.6601
14	.55118	45.93167	8.69918	3.69849	30.8647
15	.59055	49.21250	9.32055	3.96266	33.0693
16	.62992	52.49333	9.94192	4.22684	35.2740
17	.66929	55.77417	10.56329	4.49102	37.4786
18	.70866	59.05500	11.18466	4.75520	39.6832
19	.74803	62.33583	11.80603	5.01937	41.8878
20	.78740	65.61667	12.42740	5.28355	44.0924
21	.82677	68.89750	13.04877	5.54773	46.2971
22	.86614	72.17833	13.67014	5.81191	48.5017
23	.90551	75.45917	14.29151	6.07608	50.7063
24	.94488	78.74000	14.91288	6.34026	52.9109
25	.98425	82.02083	15.53425	6.60444	55.1156
26	1.02362	85.30167	16.15562	6.86862	57.3202
27	1.06299	88.58250	16.77699	7.13280	59.5248
28	1.10236	91.86333	17.39836	7.39697	61.7294
29	1.14173	95.14417	18.01973	7.66115	63.9340
30	1.18110	98.42500	18.64110	7.92533	66.1387
31	1.22047	101.70583	19.26247	8.18951	68.3433
32	1.25984	104.98667	19.88384	8.45368	70.5479
33	1.29921	108.26750	20.50521	8.71786	72.7525
34	1.33858	111.54833	21.12658	8.98204	74.9572
35	1.37795	114.82917	21.74795	9.24622	77.1618
36	1.41732	118.11000	22.36932	9.51039	79.3664
37	1.45669	121.39083	22.99069	9.77457	81.5710
38	1.49606	124.67167	23.61206	10.03875	83.7756
39	1.53543	127.95250	24.23343	10.30293	85.9803
40	1.57480	131.23330	24.85480	10.56710	88.1849
41	1.61417	134.51417	25.47617	10.83128	90.3895
42	1.65354	137.79500	26.09754	11.09546	92.5941
43	1.69291	141.07583	26.71891	11.35964	94.7988
44	1.73228	144.35667	27.34028	11.62381	97.0034
45	1.77165	147.63750	27.96165	11.88799	99.2080
46	1.81102	150.91833	28.58302	12.15217	101.4126
47	1.85039	154.19917	29.20439	12.41635	103.6173
48	1.88976	157.48000	29.82576	12.68052	105.8219
49	1.92913	160.76083	30.44713	12.94470	108.0265
50	1.96850	164.04167	31.06850	13.20888	110.2311
100	3.93700	328.08334	62.13700	26.41776	220.4622

METRIC CONVERSION TABLES

ENGLISH TO METRIC

English Units	Hundredths of an Inch to M/M	Feet to Meters	Miles to Kilometers	Gallons to Liters	Pounds to Kilometers
1	0.254	0.30480	1.6093	3.7853	0.45359
2	0.508	.60960	3.2187	7.5707	.90718
3	0.762	.91440	4.8280	11.3560	1.36078
4	1.016	1.21920	6.4374	15.1413	1.81437
5	1.270	1.52400	8.0467	18.9267	2.26796
6	1.524	1.82880	9.6561	22.7120	2.72155
7	1.778	2.13360	11.2654	26.4973	3.17515
8	2.032	2.43840	12.8748	30.2827	3.62874
9	2.286	2.74321	14.4841	34.0680	4.08233
10	2.540	3.04801	16.0935	37.8533	4.53592
11	2.794	3.35281	17.7028	41.6387	4.98552
12	3.048	3.65761	19.3122	45.4240	5.44311
13	3.302	3.96241	20.9215	49.2093	5.89670
14	3.556	4.26721	22.5309	52.9947	6.35029
15	3.810	4.57201	24.1402	56.7800	6.80389
16	4.064	4.87681	25.7496	60.5653	7.25748
17	4.318	5.18161	27.3589	64.3506	7.71107
18	4.572	5.48641	28.9682	68.1360	8.16466
19	4.826	5.79121	30.5776	71.9213	8.61826
20	5.080	6.09601	32.1869	75.7066	9.07185
21	5.334	6.40081	33.7963	79.4920	9.52544
22	5.588	6.70561	35.4056	83.2773	9.97903
23	5.842	7.01041	37.0150	87.0626	10.43263
24	6.096	7.31521	38.6243	90.8480	10.88622
25	6.350	7.62002	40.2337	94.6333	11.33981
26	6.604	7.92482	41.8430	98.4186	11.79340
27	6.858	8.22962	43.4524	102.2040	12.24700
28	7.112	8.53442	45.0617	105.9893	12.70059
29	7.366	8.83922	46.6711	109.7746	13.15418
30	7.620	9.14402	48.2804	113.5600	13.60777
31	7.874	9.44882	49.8898	117.3453	14.06137
32	8.128	9.75362	51.4991	121.1306	14.51496
33	8.382	10.05842	53.1085	124.9160	14.96855
34	8.636	10.36322	54.7178	128.7013	15.42214
35	8.890	10.66802	56.3272	132.4866	15.87573
36	9.144	10.97282	57.9365	136.2720	16.32933
37	9.398	11.27762	59.5458	140.0573	16.78292
38	9.652	11.58242	61.1552	143.8426	17.23651
39	9.906	11.88722	62.7645	147.6280	17.69010
40	10.160	12.19202	64.3739	151.4133	18.14370
41	10.414	12.49682	65.9832	155.1986	18.59729
42	10.668	12.80163	67.5926	158.9840	19.05088
43	10.922	13.10643	69.2019	162.7693	19.50447
44	11.176	13.41123	70.8113	166.5546	19.95807
45	11.430	13.71603	72.4206	170.3400	20.41166
46	11.684	14.02083	74.0300	174.1253	20.86525
47	11.938	14.32563	75.6393	177.9106	21.31880
48	12.192	14.63043	77.2487	181.6960	21.77244
49	12.446	14.93523	78.8580	185.4813	22.22603
50	12.700	15.24003	80.4674	189.2666	22.67962
100	25.400	30.48006	160.9347	378.5330	45.35924

SPECIFIC GRAVITY EQUIVALENTS FOR DEGREES BEAUMÉ FOR LIQUIDS LIGHTER THAN WATER

FORMULA: DEGREES BEAUMÉ = $\dfrac{140}{\text{SP. GR.} \frac{60°}{60°} \text{F.}} = 130$

SP. GR. TAKEN AT 60° F. AND REFERRED TO DISTILLED WATER AT 60° F

Beaumé	Specific Gravity	Pounds Per Gallon	Beaumé	Specific Gravity	Pounds Per Gallon	Beaumé	Specific Gravity	Pounds Per Gallon
10	1.0000	8.33	37	.8383	6.98	64	.7217	6.01
11	.9929	8.27	38	.8333	6.94	65	.7179	5.98
12	.9859	8.21	39	.8285	6.90	66	.7143	5.95
13	.9790	8.16	40	.8235	6.86	67	.7107	5.92
14	.9722	8.10	41	.8187	6.82	68	.7071	5.89
15	.9655	8.04	42	.8139	6.78	69	.7035	5.86
16	.9589	7.99	43	.8092	6.74	70	.7000	5.83
17	.9524	7.93	44	.8046	6.70	71	.6965	5.80
18	.9459	7.88	45	.8000	6.66	72	.6931	5.78
19	.9396	7.83	46	.7955	6.63	73	.6897	5.75
20	.9333	7.78	47	.7909	6.59	74	.6863	5.72
21	.9272	7.72	48	.7865	6.55	75	.6829	5.69
22	.9211	7.67	49	.7821	6.52	76	.6796	5.66
23	.9150	7.62	50	.7777	6.48	77	.6763	5.63
24	.9091	7.57	51	.7735	6.44	78	.6730	5.60
25	.9032	7.53	52	.7692	6.41	79	.6698	5.58
26	.8974	7.48	53	.7650	6.37	80	.6666	5.55
27	.8917	7.43	54	.7609	6.34	81	.6635	5.52
28	.8861	7.38	55	.7568	6.30	82	.6604	5.50
29	.8805	7.34	56	.7527	6.27	83	.6573	5.48
30	.8750	7.29	57	.7487	6.24	84	.6542	5.45
31	.8696	7.24	58	.7447	6.20	85	.6511	5.42
32	.8642	7.20	59	.7407	6.17	86	.6481	5.40
33	.8589	7.15	60	.7368	6.14	87	.6451	5.38
34	.8537	7.11	61	.7329	6.11	88	.6422	5.36
35	.8485	7.07	62	.7292	6.07	89	.6392	5.33
36	.8433	7.03	63	.7254	6.04	90	.6363	5.30

MEMORANDUM

PART XXII

MODEL H—300 H. P. HISPANO-SUIZA ENGINE PARTS CATALOGUE

Part No.	No. Per Engine	Name of Part
B-27	1	½″ ID 45/64″ OD x 5/64″ thick Gasket
B-28	18	47/64″ ID $\frac{15}{16}$″ OD x 5/64″ thick Gasket
B-32	1	2$\frac{17}{32}$″ ID 2$\frac{27}{32}$″ OD x $\frac{3}{16}$″ thick Gasket
B-64	20	Cotterpins 5/64″ diam. x 1″ long
B-93	34	6 m/m x 1 P. Nut—$\frac{13}{32}$″ hex.
T-129	2	Camshaft Gear Key
T-210	6	8 m/m x 1.25 P. Stud, x 1$\frac{1}{16}$″ long
656	2	Cotterpins $\frac{3}{32}$″ diam. x ¾″ long
657	10	Cotterpins $\frac{3}{32}$″ diam. 1″ long
B-754	1	6 m/m x 53/64″ $\frac{7}{16}$″ dia. Lock Screw
B-759	1	1½″ ID 1$\frac{31}{32}$″ OD x $\frac{3}{32}$″ thick Gasket
B-760	1	$\frac{23}{32}$″ ID x 1$\frac{1}{32}$″ OD x 5/64″ thick Oil Manifold Plug Gasket
B-761	2	31/64″ ID $\frac{25}{32}$″ OD x 5/64 thick Gasket
B-767	8	.315″ dia. x ⅝″ Dowel
B-768	18	.236″ dia. x ⅝″ Dowel
B-777	2	.158″ dia. x 25/64″ Dowel
B-780	1	1$\frac{3}{16}$″ 1 27/64″ OD x 5/64″ thick ID Gasket
B-781	2	Propeller Hub Key Screw
B-784	6	Stud, 6 m/m dia. x 1 P. x 1 9/64″ long
B-789	33	Lockwasher for 6 m/m dia.
B-790	70	Lockwasher for 8 m/m dia.
B-794	16	6 m/m x P. x 61/64″ Stud
B-803	9	5 m/m x .75 P.x $\frac{5}{16}$″ Fill.Head Mach. Screw
B-807	1	Magneto B. B. Nut Lock Spring
T-853	2	No. 2 Taperpin x 1¼″ long
B-930	8	Crankshaft Bearing Stud, Center
B-933	24	12 m/m x 1.75 m/m Special Nut

Part No.	No. Per Engine	Name of Part
B-934	4	Dowel Screw, 8 m/m x 1.25 P.
B-938	12	Cylinder Stud, 12 m/m x 1.75 P.
T-948	12	8 m/m x 1.25 P. x 3 $\frac{5}{32}$″ Stud
T-949	8	Stud, 8 m/m x 1.25 P. x 1 17/64″ long
B-950	24	Cylinder Cover Screw Bushing
T-952	8	Camshaft Center Bearing Screws
T-954	18	8 m/m x 1.25 P. Stud, x 1 $\frac{11}{32}$″ long
T-961	5	Stud, 8 m/m x 1.25 P. x 1-$\frac{3}{16}$″ long
T-964	16	Stud, 8 m/m x 1.25 P. x 1$\frac{5}{32}$″ long
T-984	2	Oil Pipe Flange Gasket
T-989	2	Oil Pipe Nipple
T-990	2	Oil Pipe Nipple Packing Nut
T-1037	4	Oil Pipe Bracket Screws
T-1092	8	Water Pipe Gasket
1426	1	Magneto Support Gasket
1437	4	$\frac{5}{16}$″ dia. x ¾″ Dowel
1440	8	Magneto Cap Screws
1441	3	10 m/m x 1.5 P. x 1$\frac{5}{16}$″ Stud
1442	5	10 m/m x 1.5 P. x 1$\frac{5}{32}$″ Stud
1443	5	10 m/m x 1.5 P. x ⅜″ Slotted Nut
1444	3	10 m/m x 1.5 P. Plain Nut
1458	13	$\frac{13}{32}$″ ID Plain Washer
6204	2	H.B. Ball Bearing No. 6204
6207	1	H.B. Ball Bearing No. 6207
6409	1	H.B. Ball Bearing No. 6409
9619	2	Camshaft Bearing, Front
9638	1	Crankshaft Gear
9667	43	38 m/m x 1.5 m/m P. Plug
9939	2	Camshaft Front Bearing Washer
9943	2	Oil Pipe Flange
9960	1	Breather Cap
10377	2	Water Pump Thrust Button
10433	1	18 m/m x 1.5 m/m Plug
10435	1	Oil Manifold Cap
10487	2	Vertical Shaft Casing Nut Lock Ring
10491	1	30 m/m x 1.5 P. Plug
10561	1	Tachometer Coupling

Part No.	No. Per Engine	Name of Part
10637	1	Crankshaft Centering Lock Nut
10693	1	Crankshaft Centering Nut Lock
10729	2	Camshaft Nut
10768	1	Water Pump Bushing
10770	1	Water Pump Gland Nut
11041	2	Camshaft Oil Tube Bracket
11053	1	Oil Manifold Plug
11137	2	Water Hole Plate
11160	2	Wire Manifold End Tube
11161	4	.066″-072″ x $\frac{3}{16}$″ R. H. Rivet
11163	8	Connecting Rod Bushing Dowel
11168	1	$\frac{1}{8}$″ Packing
11169	48	Cotterpins
11188		Cord Packing
11206	1	Tachometer Coupling Pin
11208		$\frac{1}{16}$″ dia. Wire
11214	1	Motor License Plate
11233	1	$\frac{3}{4}$″ Pipe Plug
11240	1	28 m/m x 1.5 P. Special Nut
11302	12	8 m/m x 1.25 P. Slotted Nut
11303	93	8 m/m x 1.25 P. Nut, x $\frac{5}{16}$″
11305	64	10 m/m x 1.5 P. x $\frac{15}{32}$″ long, Nut
11322	4	$\frac{3}{16}$″ dia. x $\frac{1}{2}$″ long, Flat Head Rivet
11323	8	Crankshaft Plug, 25 m/m
11324	4	Crankshaft Plug, Small
11326		Ignition Wire
11330	1	Name Plate
11332		Aero Engine Brown Metal Baking Paste
11333		Aero Engine Brown Metal Baking Primer
11334		Special Aero First Coater
11335		Aero Aluminum Finishing Japan, Special
11340	16	Ignition Wire Terminals
11348	2	$\frac{1}{8}$″ dia. $1\frac{1}{2}$″ long Cotterpins
11373	2	Camshaft Center Bearing
11374	2	Camshaft Center Bearing Cap
11375	2	Camshaft Rear Bearing

Part No.	No. Per Engine	Name of Part
11386	6	6 m/m x 1 P. x 7/8" long, Stud, 5/16" diam.
11387	1	Water Pump Shaft
11397	1	Propeller Hub Nut Lock Ring
11402	2	Vertical Shaft Bearing, Upper
11403	2	Camshaft Gear
11406	16	Valve Spring, Inner
11407	16	Valve Spring, Outer
11429	1	Ignition Manifold
11440	44	1½" ID x 1 49/64" OD Gasket
11442	2	Ignition Manifold Straps
11449	8	Ignition Wire Ring, large
11468	1	Tachometer Drive Shaft
11469	1	Tachometer Drive Shaft Bushing
11473	1	Cylinder Water Jacket, R. H.
11474	1	Cylinder Water Jacket, L. H.
11478	3	Oil Manifold Tube
11480	1	Water Pump Cover Gasket
11485	8	Valve Guide, Exhaust
11486	1	Crankshaft Front Bearing, Lower
11487	3	Crankshaft Inter. Bearing, Lower
11488	4	Connecting Rod Bearing
11489	4	Connecting Rod Bearing Cap
11491	32	Piston Ring
11493	8	Connecting Rod Bushing
11494	8	Piston Pin
11497	2	Vertical Shaft Casing Nut
11503	16	Inner Connecting Rod Bolt Nut
11506	16	Inner Connecting Rod Bolt
11507	8	Outer Connecting Rod Bolt
11508	8	Outer Connecting Rod Bolt Nut
11510	2	Cyl. Flange Gasket
11511	2	Cyl. Cover Gasket
11513	16	Valve Spring Washer, Lower
11517	6	8 m/m x 1.25 P. x 1 3/32" Bolt
11520	2	Crankshaft Bearing Stud, Front
11524	64	10 m/m x 1 m/m P. Cylinder Stud
11525	1	Thrust Bearing Lock Ring
11527	1	Oil Pressure Relief Body

Part No.	No. Per Engine	Name of Part
11530	1	Oil Pressure Relief Spring
11531	1	Oil Pressure Relief Plunger
11532	1	Magneto Adv. Thrust Bearing Lock Ring
11544	8	Valve Tappet Washer (Admission)
11548	4	Adm. Manifold Gasket
11567	1	Magneto Advance Shaft Bushing
11568	8	Admission Valve Guide
11569	2	Camshaft
11570	2 Sets	Ignition Wire Markers
11574	16	Spark Plug Bushing Gaskets
11612	1	Oil Manifold Tube Plug
11615	1	64 m/m x 2 m/m P. Plug
11626	1	Propeller Hub Key
11630		Soft Iron Wire, .030″ to .045″ thick
11640	2	Vertical Shaft Gear, Lower
11657	1	Magneto Pinion
11666	4	Connecting Rod, Outer
11667	4	Connecting Rod, Inner
11669	8	Cylinder Sleeve
11677	26	Cylinder Cover Screw
11680	5	Magneto Coupling Gear Key
11694		Black (Kwick-Work) Auto Enamel
11696	1	Magneto Advance Shaft Lever
11697	1	Magneto Advance Locating Pin
11698	1	Magneto Advance Disc.
11699	1	Magneto Advance Shaft
11700	2	6 m/m x 1 P. Cts'k. Fill. Head Screw
11701	1	Magneto Advance Handle
11702	1	Magneto Advance Locating Pin Nut
11703	1	Magneto Advance Locating Pin Spring
11705	1	21/64″ ID x 5/8″ OD x 1/16″ Washer
11706	1	Cotterpin
11707	16	Cotterpins
11721	2	Camshaft Oil Tube
11725	2	Vertical Shaft Casing, Upper
11728	2	Vertical Shaft Gear, Upper
11729	2	Vertical Shaft Gear Collar, Upper

Part Po.	No. Per Engine	Name of Part
11730	2	Vertical Shaft Thrust Washer
11731	8	Piston
11732	2	Head Pin for Vert. Shaft Lower Gear
11733	1	Crankshaft Gear Washer
11734	1	Chankshaft B. B. Washer
11739	8	Exhaust Pipe Flange
11740	8	Exhaust Pipe Flange Gasket
11744	28	Magneto Advance Ball
11747	1	Oil Suction Pump Body
11748	1	Oil Pressure Pump Body
11749	1	Oil Filter Chamber Cover
11750	1	Oi Pump Gear Bearing, Front Half
11751	1	Oil Pump Gear Bearing, Rear Half
11752	3	Oil Pump—Drive Gear
11753	1	Gear Pump Drive Pinion
11754	2	Oil Suction Pump Gear
11755	1	Oil Pressure Pump Gear
11756	2	Oil Suction Pump Idler Gear
11757	1	Oil Pressure Pump Idler Gear
11758	1	Water Pump Drive Shaft
11759	1	Oil Filter Ring
11760	1	Oil Filter Screen
11761	1	Oil Filter Spring
11762	1	Water Pump Drive Shaft Spring
11763	16	Piston Pin Guide Plug
11764	3	10 m/m x 1.5 m/m P. Castled Nut
11767	10	8 m/m x 1.25 P. x 1 $\frac{7}{32}$" Stud
11768	4	Oil Pump Gear Bearing Screw
11770	1	Crankcase, Lower Half
11773	2	Cyl. Water Inlet Connection
11774	2	Cyl. Water Outlet Connection
11775	1	Oil Pump Gear Bearing Set Screw
11776	2	21 m/m Hose Connection
11778	16	Spark Plug Bushing
11787	1	Breather Tube Valve Stem
11782	1	Running Magneto L. H.
11783	1	Starting Magneto
11788	1	Breather Tube Valve
11791	1	Breather Tube

Part No.	No. Per Engine	Name of Part
11796	1	1/8″ Spring Key Cock
11810	1	Crankcase, Upper Half
11811	1	Oil Manifold Tube, long
11812	1	Propeller Thrust Bearing Ring
11821	1	Oil Pump Suction Pipe Bkt. Rear
11822	1	Oil Pump Suction Pipe Bkt. Front
11836	1	Oil Suction Pipe Clip
11844	13	8 m/m x 1.25 P. x 1 $\frac{13}{32}$″ long, Stud
11845	1	Oil Suction Pump Screen Reinf.
11846	1	Propeller Hub Flange
11848	8	Propeller Hub Bolt
11849	8	Propeller Hub Bolt Nut
11850	1	Oil Suction Pump Screen, Front
11851	3	6 m/m x 1 P. x 1 $\frac{21}{32}$″ Stud
11852	1	6 m/m x $\frac{15}{32}$″ Fill. Head Screw
11854	1	Oil Pump Suction Pipe Bkt. Gasket, Front
11855	1	Oil Suction Pipe Bracket Gasket, Rear
11856	1	Oil Filter Chamber Cover Gasket
11858	1	Oil Suction Pump Screen, Rear
11860	1	Oil Pump Suction Pipe
11866	2	Crankcase Rear Bearing Stud
11867	1	Magneto Support Cover Gasket
11868	2	$\frac{13}{16}$″ ID Gasket
11870	3	$\frac{13}{16}$″ OD x $\frac{11}{32}$″ ID Washer
11871	1	Running Magneto R. H.
11878	1	Crankshaft
11880	1	Propeller Thrust Bearing
11887	1	Propeller Hub
11893	1	Oil Pressure Relief Cap
11894	1	Water Pump Impeller
11895	1	Water Pump Cover
11896	2	Magneto Coupling Spring
11897	2	Magneto Coupling
11898	2	Magneto Coupling Spring Washer
11899	2	Magneto Pinion Nut
11900	2	Magneto Shaft Gear Nut
11901	24	R. H. Iron Rivet

Part No.	No. Per Engine	Name of Part
11902	2	Magneto Pinion B. B. Nut
11903	2	Magneto Coupling Gear, 23 Teeth
11904	2	Magneto Coupling Gear, 24 Teeth
11905	2	Magneto Drive Shaft Gear, 24 Teeth
11906	2	Magneto Shaft Gear, 23 Teeth
11916	1	Oil Pump Cover Plate
11917	1	Water Pump Drive Shaft Bushing
11918	1	Oil Pump Cover Plate Gasket
11919	1	Oil Pump Screen Reinf. Rear
11927	1	Magneto Supp. Cover & B. B. Retainer
11929	1	Oil Pressure Gage Hose Connection
11934	1	Magneto Advance Shaft Spring
11937	2	Cyl. Cover Screw Dowel Bushing
11944	1	Oil Manifold
11945	2	Cotterpins
11962	2	8 m/m x 1.25 P. x $1\frac{1}{16}''$ Stud
11967	32	8 m/m x 1.25 P. x $\frac{3}{8}''$ Bronze Nut
11968	32	8 m/m x 1.25 P. x $1\frac{3}{8}''$ Titted Stud
11969	8	Exhaust Valve
11970	8	Valve Tappet Washer, Exhaust
11972	16	Valve Tappet
11973	4	Priming Cups
12053	11	Round Head Machine Screw
13116	1	Magneto Support-Bracket
13121	1	Magneto Advance Link
13122	1	Magneto Advance Yoke
13123	1	Head Pin, .315" dia. x $\frac{7}{8}''$ long
13125	1	Magneto Advance Yoke Fulcrum Pin
13126	1	Magneto Shaft Pinion
13127	1	Magneto Drive Gear Shaft
13128	1	Magneto Adv. Gear Reaction Spring
13129	1	Magneto Adv. Thrust Bearing Ring
13130	1	Magneto Adv. Thrust Bearing Nut
13288	1	Cylinder Cover L. H.
13289	1	Cylinder Cover R. H
13291	3	Crankshaft Inter. Bearing, Upper
13292	8	Admission Valve
13294	1	Crankshaft Front Bearing, Upper

Part No.	No. Per Engine	Name of Part
13320	1	Thrust Bearing Nut
13329	1	Water Pump Body
11984	1	U. S. Standard Name Plate
11981	4	Cyl. Ignition Wire Manifold
11982	8	Cyl. Ignition Wire Manifold Clip
11983	16	$\frac{5}{32}$″ dia. x ¼″ Flat Head Rivet
11971	8	8 m/m x 1.25 P. x ⅞″ Stud
11913	1	Propeller Hub Nut, Inner
11914	1	Propeller Hub Nut, Outer
14018	1	Envelope for Engine Log Book
11999	1	Engine Log Book
14057	1	Propeller Hub Dowel

MACHINE-GUN CONTROL DRIVE

11951	2	Interrupter Gear Shaft
11953	2	Interrupter Gear Shaft B. B. Nut
6203	4	HB Ball Bearing No. 6203
11946	2	Interrupter Ball Bearing Spacer
11680	2	Key
11899	2	12 m/m x 1.25 P. x $\frac{5}{16}$″ Slotted Nut
657	2	Cotterpins
B-64	2	Cotterpins
14023	2	Interrupter Brace Stud
14024	2	Interrupter Brace Spring
14025	2	21/64″ x ¾″ O D x $\frac{1}{16}$″ Thick
11949	2	Interrupter Gear Shaft Housing
14008	2	Interrupter Drive Gear
10357	2	Vertical Shaft Gear Hous. Pack. Nut
10685	2	Vertical Shaft Gear Hous. Gasket
11366	2	Vertical Shaft Lower Bearing Screw
11960	2	Interrupter Gear Shaft Housing Gasket
14009	2	Interrupter Drive Pinion
14010	2	Vertical Shaft Bearing (Lower)
14012	2	Interrupter Drive Gear Housing
14013	2	Interrupter Gear Housing Cover

NA-D6 STROMBERG CARBURETOR USED ON FIRST 500 ENGINES

Part No.	No. Per Engine	Name of Part
B-28	9	47/64″ ID Gasket
B-93	6	6 m/m x 1 P. Nut
B-782	4	Stud, 8 m/m x 1.25 P. x 1 1/32″ long
B-789	6	Lockwasher for 6 m/m dia.
B-803	2	5 m/m x .75 P. x 5/16″ Fill Head Screw
9667	3	38 m/m x 1.5 P. Plug
10433	4	18 m/m x 1.5 P. Plug
10830	2	Water Outlet Flange
11303	4	8 m/m x 1.25 P. x 5/16″ Nut
11379	5	Connection for 5/8″ ID Hose
11440	3	1½″ ID Gasket
11443	10	Straight Pin
11512	16	Spark Plugs
11546	1	Carburetor Flange Gasket
11547	2	Admission Manifold Tee Gasket
11566	1	Admission Manifold Filler Ring
11796	1	1/8″ Spring Key Cock
11837	1	Carburetor (Type NA-D6 Stromberg)
11891	1	Carburetor Support
11922	1	Admission Manifold Extension
11923	1	Admission Manifold Adjusting Extension
11966	6	Stud, 6 m/m x 1 P. x 1¼″ long
12277	2	Inlet Tube Lock
13428	1	Admission Manifold Tee
13429	2	Admission Manifold

NA-V6 STROMBERG CARBURETOR USED AFTER FIRST 500 ENGINES

13433	1	Admission Manifold Packing Nut
B-64	6	Cotterpin
11137	2	Water Hole Plate
11302	6	8 m/m x 1.35 P. Slotted Nut
11974	2	Admission Manifold
11975	2	Carburetor Extension
11976	2	Admission Manifold Packing Nut

Part No.	No. Per Engine	Name of Part
11977	2	Carburetor Extension Gasket
11978	6	8 m/m x 1.25 P. x $1\frac{3}{16}''$ Drilled Bolt
11979		Carburetor Support

LIST OF SPECIAL TOOLS AND PARTS SHIPPED WITH EACH MODEL H 300 H. P. HISPANO-SUIZA ENGINE.

11986	1	Carburetor (Type NA-V6 Stromberg)
11144	1	Valve Adjusting Wrench Handle
11315	1	Single End Wrench for $\frac{9}{16}''$ hex.
12221	1	Propeller Hub Nut Wrench Assembly
11987	2	Valve Clearance Gauge
12172	1	Assorted Cotterpins Assembly
14049	1	Water, Oil Pump & Vert. Shaft Nut Wrench
14050	1	Adjustable Hook Spanner Wrench
14051	1	Adjustable Hook Spanner Wrench
14052	1	Spark Plug Wrench
14053	1	$\frac{3}{8}''$ dia. Wrench Handle
14054	1	Cylinder Stud Nut Wrench
14055	1	Valve Adjusting Wrench
14056	2	Valve Adjusting Wrench Pins
14062	1	$\frac{11}{16}''$ hex. Socket Wrench
12226	1	Piston Pin Plug Remover
14077	1	Instruction Book
14078	1	Tool Box
14079	1	Spare Parts Box
11785	1	Magneto Repair Kit (Simms)
11229	1	Magneto Repair Kit (Dixie)

MEMORANDUM

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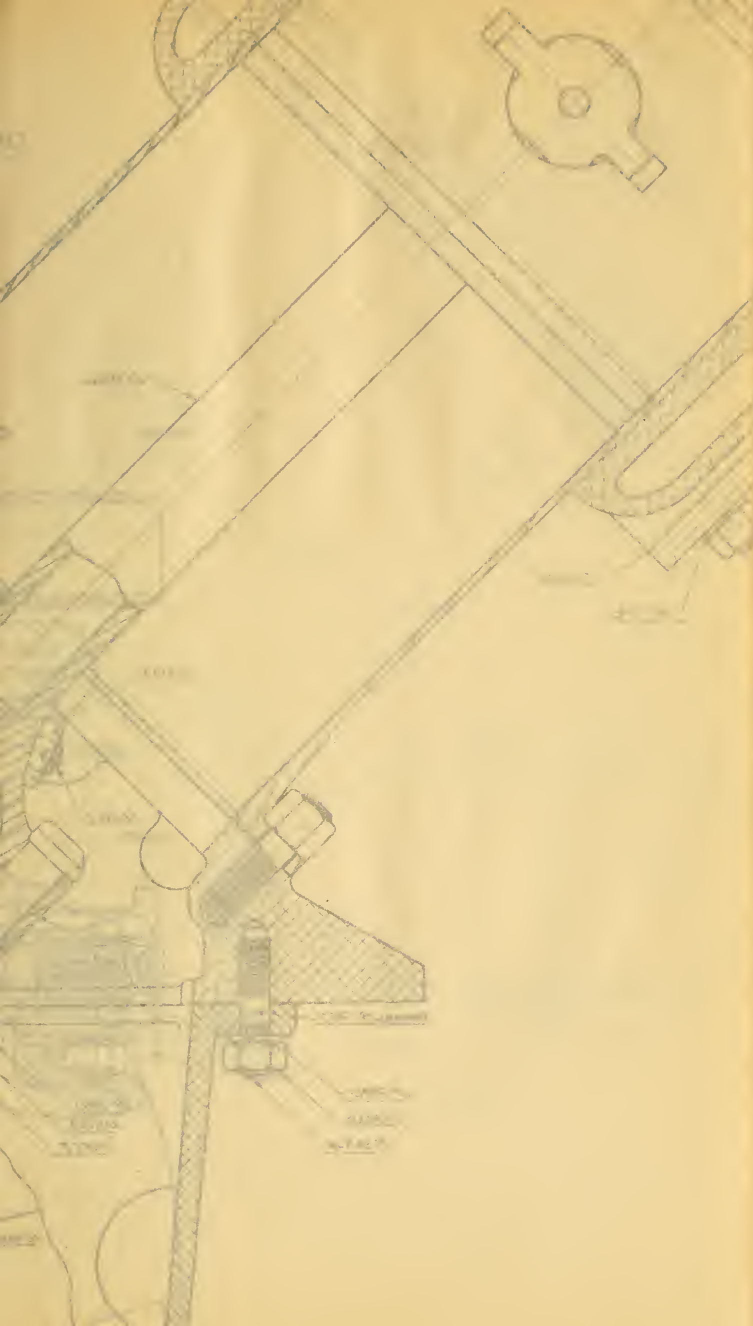


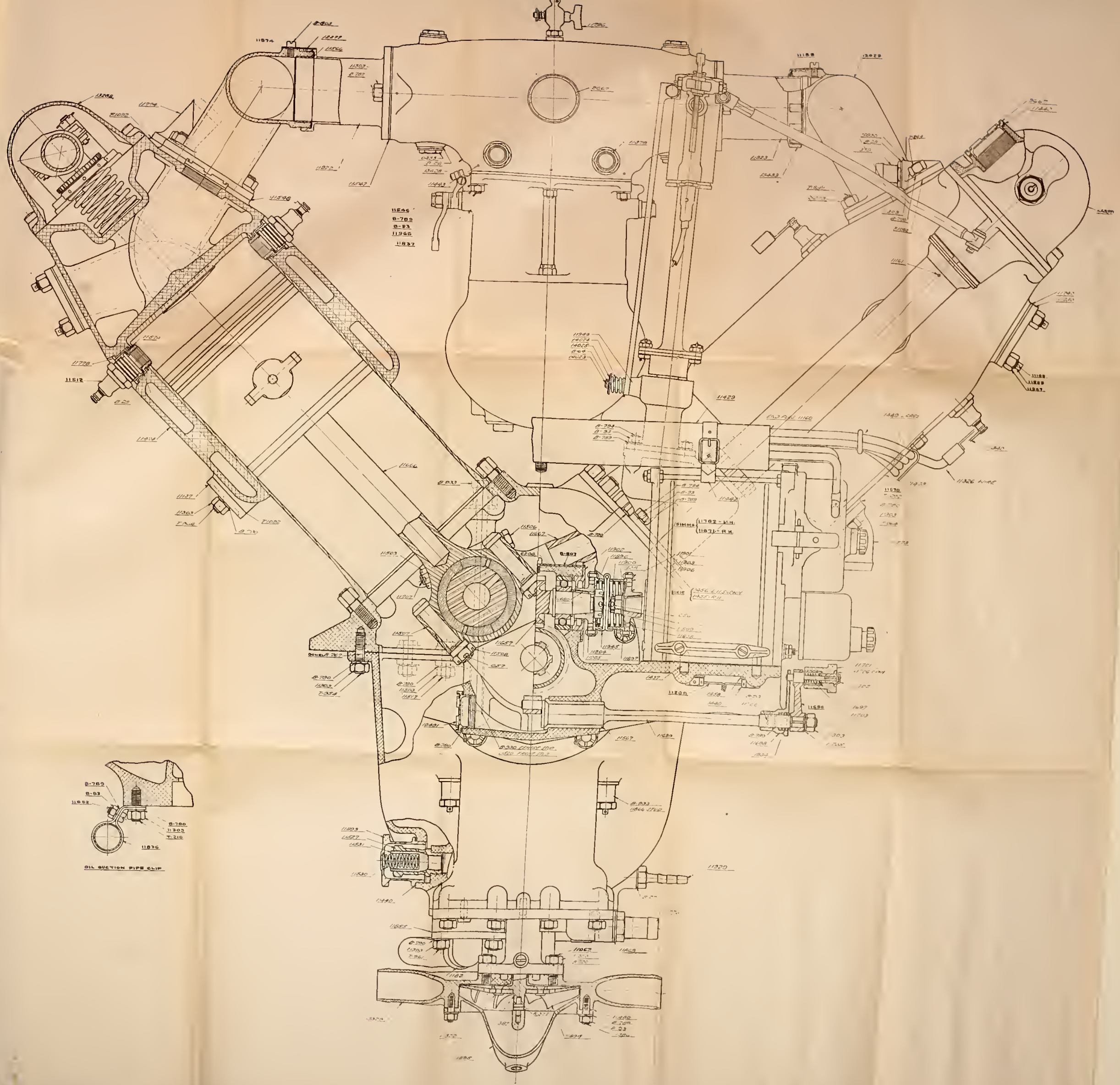


Plate 53

Section—End View Assembly with Vertical Carburetor

Approximately half size

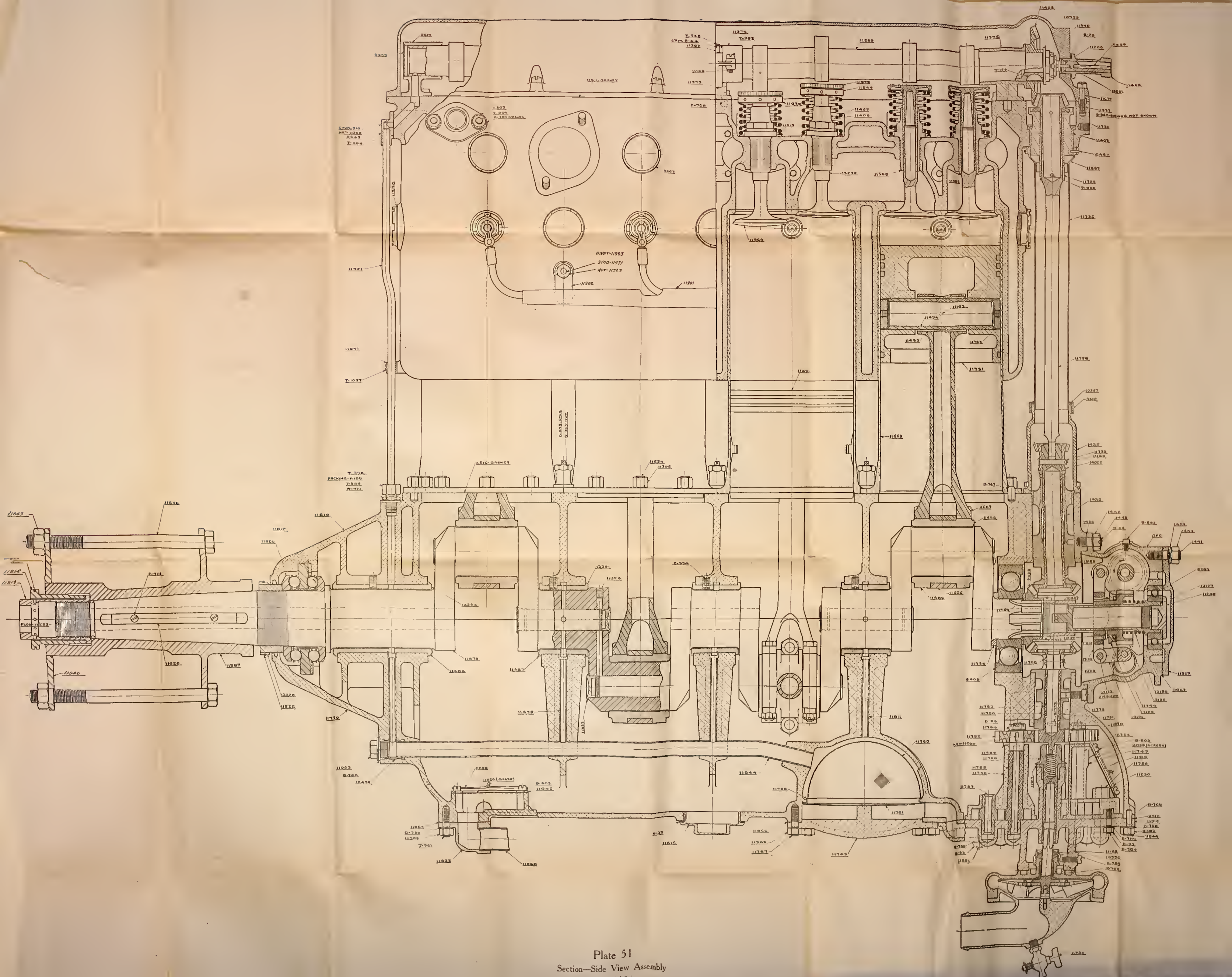
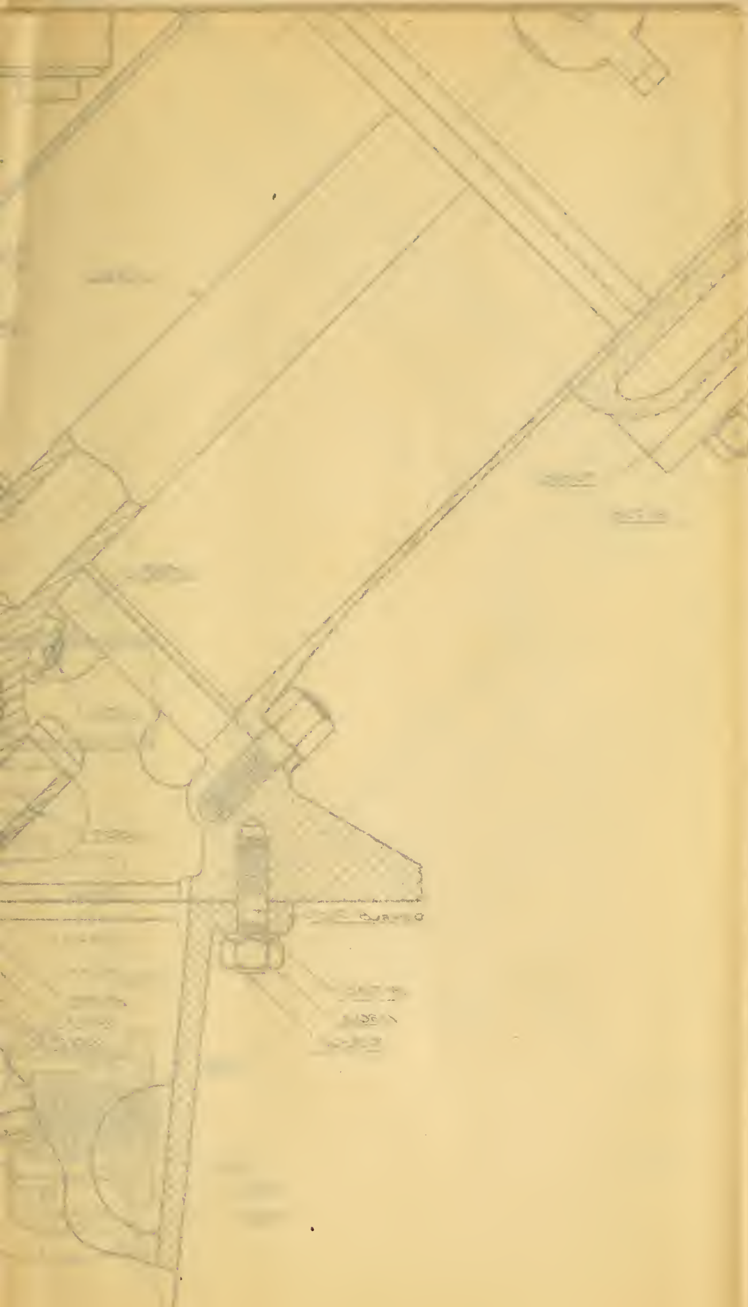


Plate 51
Section—Side View Assembly
Approximately half size



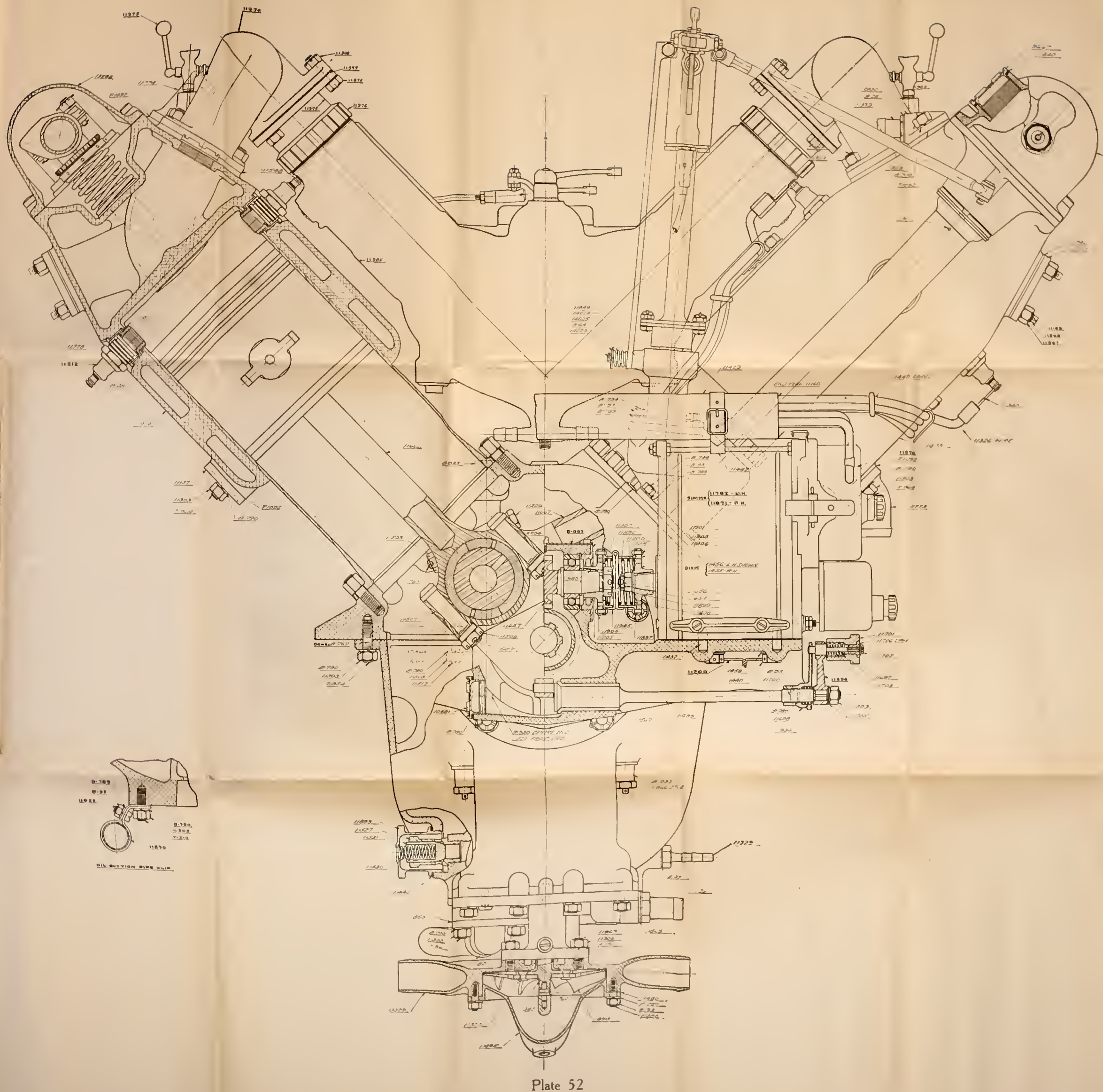


Plate 52

Section—End View Assembly with Vee Carburetor

Approximately half size

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